In [ ]:
```
import pandas as pd
import os, sys, pandas, pathlib, time
import collections
from collections import defaultdict
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
import torch
import torch.nn as nn
import torch.optim as optim
import torchvision
from torchvision import datasets, transforms
from torchvision.transforms import v2
from torchvision.io import read_image
from torch.utils.data import Dataset, DataLoader
from PIL import Image
import cv2
import numpy as np
from tqdm import tqdm, trange
from sklearn.metrics import accuracy_score, f1_score, confusion_matrix
import random

Image.MAX_IMAGE_PIXELS = None #Throws error if size of images exceeds this number
```

In [ ]:
```
#Creates dictionary mapping labels(string) to vector(one-hot encoding)
all_labels = list(np.load('materials/UBC-OCEAN_CS640/all_labels.npy'))
num_classes = len(all_labels)
label_dict = defaultdict(lambda: torch.zeros(num_classes))
for i, label in enumerate(all_labels):
    label_dict[label][i] = 1
```

In [ ]:
```
    # change the size only if necessary
transform = v2.Compose([v2.Resize(512, antialias = True),
                            v2.CenterCrop(448),
                            v2.ToImage(),
                            v2.ToDtype(torch.float32, scale = True),
                            v2.Normalize(mean = [0.4887, 0.4266, 0.4855], std = [0.
```

In [ ]:
```
## TODO: create list of transformed images and update dataset class removing transf

def load_transform_images(folder_path):
    images = {}  # Dictionary to store transformed images

    for filename in tqdm(os.listdir(folder_path)):
        if filename.endswith('.jpg'):  # Check for .jpg files
            img_name = os.path.splitext(filename)[0]  # Extract the name (assuming
            #print(img_name)
            img_path = os.path.join(folder_path, filename)
            with Image.open(img_path) as img:
                img = img.convert('RGB')  # Convert image to RGB (if not already)
                transformed_img = transform(img)  # Apply the transformation
                images[img_name] = transformed_img  # Store in dictionary with name

    return images
```

```
# Example usage
#folder_path = 'materials/UBC-OCEAN_CS640/train_images_compressed_80/'
#transformed_images = load_transform_images(folder_path)
```

In [ ]:
```
## Create list of training images and validation images using a split
def split_dataset(images, train_ratio=0.8):
    total_images = len(images)
    train_size = int(total_images * train_ratio)

    # Randomly shuffle the images
    shuffled_items = list(images.items())
    random.shuffle(shuffled_items)

    # Split the images into training and validation sets
    train_images = dict(shuffled_items[:train_size])
    validation_images = dict(shuffled_items[train_size:])

    return train_images, validation_images

train_images, validation_images = split_dataset(transformed_images)


print(f'Number of training images: {len(train_images.keys())}')
print(f'Number of validation images: {len(validation_images.keys())}')
print(f'Type of key: {type(list(train_images.keys())[0])}')
print(f'Type of image: {type(list(train_images.values())[0])}')
print(f'Size of image: {list(train_images.values())[0].size()}')
```

```
Number of training images: 344
Number of validation images: 86
Type of key: <class 'str'>
Type of image: <class 'torchvision.tv_tensors._image.Image'>
Size of image: torch.Size([3, 448, 448])
```

In [ ]:
```
##TODO: Update dataset to pass in list of images
class CustomDataset(Dataset):
    def __init__(self, csv_file, images, num_classes):
        """
        Args:
            csv_file (string): Path to the csv file with annotations.
            root_dir (string): Directory with all the images.
            num_classes (int): Total number of classes.
            transform (callable, optional): Optional transform to be applied on a s
        """
        self.labels_frame = pd.read_csv(csv_file)

        self.name_to_id = self.labels_frame['image_id'].to_dict()
        self.id_to_name = {int(v):k for k, v in self.name_to_id.items()}

        self.images = images
        self.image_names = list(self.images.keys())  # List of image names
        self.num_classes = num_classes

    def __len__(self):
        return len(list(self.images.keys()))
```

```
    def __getitem__(self, idx):
        image = self.images[self.image_names[idx]]

        label = self.labels_frame.iloc[self.id_to_name[int(self.image_names[idx])],
        #print(self.labels_frame.iloc[self.id_to_name[int(self.image_names[idx])]])
        # Convert label to one-hot encoding
        one_hot = label_dict[str(label)]
        return image, one_hot
```

In [ ]:
```
## TODO: Add validation set and update method calls
batch_size = 8

# Create the dataset
train_dataset = CustomDataset(csv_file='materials/UBC-OCEAN_CS640/train.csv', image
validation_dataset = CustomDataset(csv_file='materials/UBC-OCEAN_CS640/train.csv',

# Create a DataLoader
train_dataloader = DataLoader(train_dataset, batch_size=batch_size, shuffle=True)
validation_dataloader = DataLoader(validation_dataset, batch_size=1, shuffle=True)

# Now you can use this dataloader in your training loop
```

In [ ]:
```
#Size of the reshaped first image in the data set
#(RGB * width * height)
print(f'Numer of training examples: {train_dataset.__len__()}')
print(f'Numer of testing examples: {validation_dataset.__len__()}')
print(f'Type of pairing: {type(train_dataset.__getitem__(0))}')
print(f'Number of inputs + outputs: {len(validation_dataset.__getitem__(0))}')
print(f'Size of input: {train_dataset.__getitem__(0)[0].size()}')
print(f'First input(normalized): {train_dataset.__getitem__(0)[0]}')
print(f'First output(one-hot encoding): {train_dataset.__getitem__(0)[1]}')
```

```
Numer of training examples: 344
Numer of testing examples: 86
Type of pairing: <class 'tuple'>
Number of inputs + outputs: 2
Size of input: torch.Size([3, 448, 448])
First input(normalized): Image([[[ 0.6460,  0.5529,  0.4970,  ..., -1.1603, -1.1603,
-1.1603],
        [ 0.6460,  0.5249,  0.3946,  ..., -1.1603, -1.1603, -1.1603],
        [ 0.5901,  0.5342,  0.4505,  ..., -1.1603, -1.1603, -1.1603],
        ...,
        [-1.1603, -1.1603, -1.1603,  ..., -1.1603, -1.1603, -1.1603],
        [-1.1603, -1.1603, -1.1603,  ..., -1.1603, -1.1603, -1.1603],
        [-1.1603, -1.1603, -1.1603,  ..., -1.1603, -1.1603, -1.1603]],

       [[ 0.6541,  0.5610,  0.5610,  ..., -1.1256, -1.1256, -1.1256],
        [ 0.6438,  0.5506,  0.5093,  ..., -1.1256, -1.1256, -1.1256],
        [ 0.5506,  0.5403,  0.5403,  ..., -1.1256, -1.1256, -1.1256],
        ...,
        [-1.1256, -1.1256, -1.1256,  ..., -1.1256, -1.1256, -1.1256],
        [-1.1256, -1.1256, -1.1256,  ..., -1.1256, -1.1256, -1.1256],
        [-1.1256, -1.1256, -1.1256,  ..., -1.1256, -1.1256, -1.1256]],

       [[ 0.7732,  0.7168,  0.7073,  ..., -1.1645, -1.1645, -1.1645],
        [ 0.7732,  0.7073,  0.6791,  ..., -1.1645, -1.1645, -1.1645],
        [ 0.7356,  0.7073,  0.6979,  ..., -1.1645, -1.1645, -1.1645],
        ...,
        [-1.1645, -1.1645, -1.1645,  ..., -1.1645, -1.1645, -1.1645],
        [-1.1645, -1.1645, -1.1645,  ..., -1.1645, -1.1645, -1.1645],
        [-1.1645, -1.1645, -1.1645,  ..., -1.1645, -1.1645, -1.1645]]], )
First output(one-hot encoding): tensor([0., 1., 0., 0., 0.])
```

In [ ]:
```python
# torch.cuda.is_available() checks and returns a Boolean True if a GPU is available
is_cuda = torch.cuda.is_available()

# If we have a GPU available, we'll set our device to GPU. We'll use this device va
if is_cuda:
    device = torch.device("cuda")
    print("GPU is available")
else:
    device = torch.device("cpu")
    print("GPU not available, CPU used")
```

```
GPU is available
```

In [ ]:
```python
class CancerCNN(nn.Module):
    def __init__(self):
        super(CancerCNN, self).__init__()
        self.conv1 = nn.Conv2d(3, 64, kernel_size=3, stride=1, padding=1)
        self.conv2 = nn.Conv2d(64, 128, kernel_size=3, stride=1, padding=1)
        self.conv3 = nn.Conv2d(128, 256, kernel_size=3, stride=1, padding=1)
        self.conv4 = nn.Conv2d(256, 512, kernel_size=3, stride=1, padding=1)
        self.conv5 = nn.Conv2d(512, 1024, kernel_size=3, stride=1, padding=1)

        self.dropout = nn.Dropout(p=0.3)

        self.fc1 = nn.Linear(1024 * 14 * 14, 2048)
```

```
        self.fc2 = nn.Linear(2048, 512)
        self.fc3 = nn.Linear(512, 5)

        self.pool = nn.MaxPool2d(kernel_size=2, stride=2, padding=0)
        self.relu = nn.ReLU()

    def forward(self, x):
        # Forward pass through the conv layers
        x = self.pool(self.relu(self.conv1(x)))
        x = self.pool(self.relu(self.conv2(x)))
        x = self.pool(self.relu(self.conv3(x)))
        x = self.pool(self.relu(self.conv4(x)))
        x = self.pool(self.relu(self.conv5(x)))

        x = x.view(-1, 1024 * 14 * 14)

        # Forward pass through the fully connected layers
        x = self.relu(self.fc1(x))
        x = self.relu(self.fc2(x))
        x = self.fc3(x)  # No activation function here, it will be applied outside

        return x
```

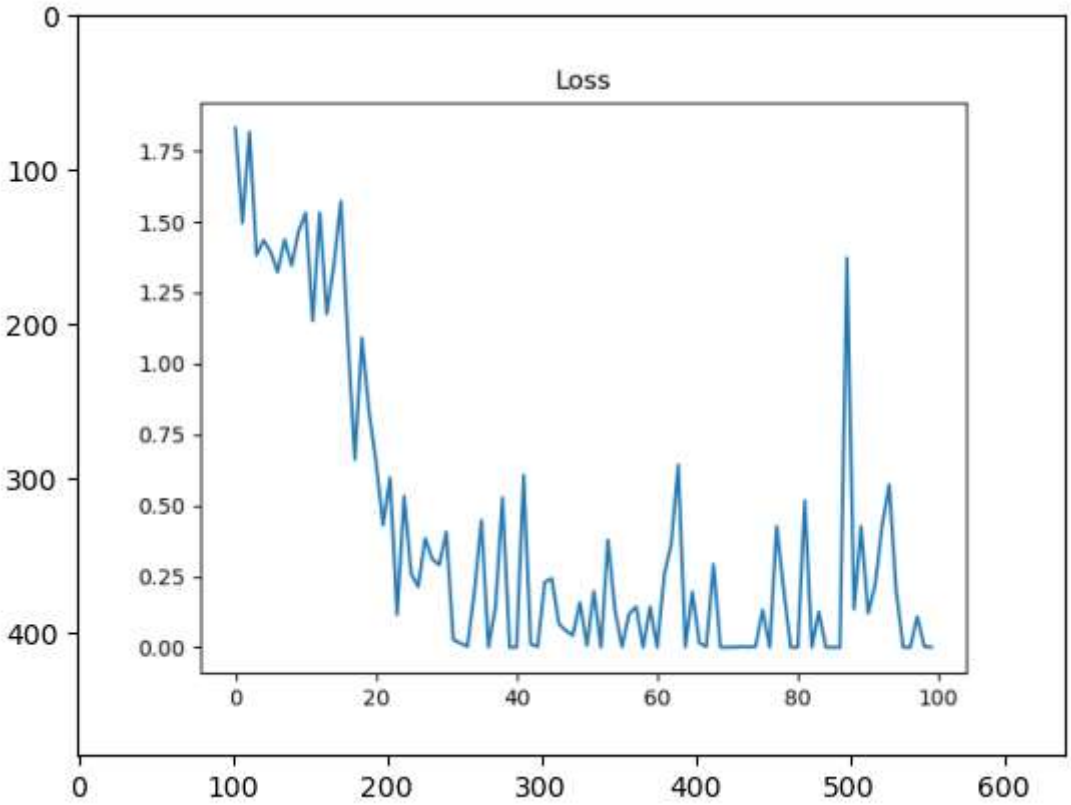
In [ ]:
```
torch.cuda.empty_cache()
```

In [ ]:
```
# Step 4: Initialize the CNN Model
model = CancerCNN().float()
print(model)

model = model.to(device)

# Step 5: Define Loss Function and Optimizer
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(model.parameters(), lr=0.001, weight_decay=1e-4)
```

```
CancerCNN(
  (conv1): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (conv2): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (conv3): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (conv4): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (conv5): Conv2d(512, 1024, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
  (dropout): Dropout(p=0.3, inplace=False)
  (fc1): Linear(in_features=200704, out_features=2048, bias=True)
  (fc2): Linear(in_features=2048, out_features=512, bias=True)
  (fc3): Linear(in_features=512, out_features=5, bias=True)
  (pool): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  (relu): ReLU()
)
```

In [ ]:
```
num_epochs = 100

losses = []


try:
    model = torch.load('Cancer_CNN_Final.pt')
```

```
    img = mpimg.imread('loss_Final.png')
    imgplot = plt.imshow(img)
    plt.show()

except:
    model.train()
    for epoch in tqdm(range(num_epochs)):  # Number of epochs
        for data, target in tqdm(train_dataloader):
            data = data.to(device)
            target = target.to(device)
            optimizer.zero_grad()
            output = model(data)
            #print(f'output: {output}')
            #print(f'target: {target.type_as(output)}\n')
            loss = criterion(output, target.type_as(output)) # Ensuring target is s
            loss.backward()
            optimizer.step()
        losses.append(loss.item())
        #print(f'Epoch {epoch+1}, Loss: {loss.item()}')
    torch.save(model, 'Cancer_CNN_Final.pt')

    fig = plt.figure()
    ax = plt.subplot(111)
    ax.plot(losses)
    plt.title('Loss')
    plt.show()
    fig.savefig('loss_Final.png')
```



In [ ]:
```
YPredict = []
YTrue = []
```

```
for data, target in tqdm(validation_dataloader):
    data = data.to(device)
    output = model(data)
    pred = int(torch.argmax(output))
    label = int(torch.argmax(target))
    YPredict.append(pred)
    YTrue.append(label)

print("Confusion matrix: " + str(confusion_matrix(YTrue, YPredict)))
print("Accuracy: " + str(accuracy_score(YTrue, YPredict)))
print("F1: " + str(f1_score(YTrue, YPredict, average = "macro")))
```

```
100%|██████████| 86/86 [00:01<00:00, 58.39it/s]
Confusion matrix: [[31  1  0  1  0]
 [ 1 16  1  0  0]
 [ 1  0  5  0  0]
 [ 3  1  1 15  0]
 [ 3  0  0  0  6]]
Accuracy: 0.8488372093023255
F1: 0.8305128205128206
```

In [ ]:
```
def load_transform_images(folder_path):
    images = {}

    for filename in tqdm(os.listdir(folder_path)):
        if filename.endswith('.jpg'):
            img_name = os.path.splitext(filename)[0]
            #print(img_name)
            img_path = os.path.join(folder_path, filename)
            with Image.open(img_path) as img:
                img = img.convert('RGB')
                transformed_img = transform(img)
                images[int(img_name)] = transformed_img  #Changed this line to int

    return images
```

In [ ]:
```
#materials\UBC-OCEAN_CS640\test.csv
# Example usage
folder_path = 'materials/UBC-OCEAN_CS640/test_images_compressed_80/'
transformed_test_images = load_transform_images(folder_path)
```

```
100%|██████████| 108/108 [04:49<00:00,  2.68s/it]
```

In [ ]:
```
print(transformed_test_images.keys())
print(all_labels)
print(label_dict)
name_dict = {int(torch.argmax(v)): k for k, v in label_dict.items()}
print(name_dict)
```

```
dict_keys([0, 1, 10, 100, 101, 102, 103, 104, 105, 106, 107, 11, 12, 13, 14, 15, 16,
17, 18, 19, 2, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 3, 30, 31, 32, 33, 34, 35, 3
6, 37, 38, 39, 4, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 5, 50, 51, 52, 53, 54, 55,
56, 57, 58, 59, 6, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 7, 70, 71, 72, 73, 74, 7
5, 76, 77, 78, 79, 8, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 9, 90, 91, 92, 93, 94,
95, 96, 97, 98, 99])
['HGSC', 'EC', 'MC', 'CC', 'LGSC']
defaultdict(<function <lambda> at 0x000001F9FD2C0720>, {'HGSC': tensor([1., 0., 0.,
0., 0.]), 'EC': tensor([0., 1., 0., 0., 0.]), 'MC': tensor([0., 0., 1., 0., 0.]), 'C
C': tensor([0., 0., 0., 1., 0.]), 'LGSC': tensor([0., 0., 0., 0., 1.])})
{0: 'HGSC', 1: 'EC', 2: 'MC', 3: 'CC', 4: 'LGSC'}
```

In [ ]:
```
test_csv = pd.read_csv('materials/UBC-OCEAN_CS640/test.csv')
print(test_csv)
```

```
     image_id  label
0           0    NaN
1           1    NaN
2           2    NaN
3           3    NaN
4           4    NaN
..        ...    ...
103       103    NaN
104       104    NaN
105       105    NaN
106       106    NaN
107       107    NaN

[108 rows x 2 columns]
```

In [ ]:
```
print(type(list(transformed_test_images.keys())[0]))
print(type(test_csv.at[0, 'image_id']))
print(list(transformed_test_images.keys())[0] == test_csv.at[0, 'image_id'])
```

```
<class 'int'>
<class 'numpy.int64'>
True
```

In [ ]:
```
for index, row in test_csv.iterrows():
    # Perform some calculation or logic here
    data = transformed_test_images[test_csv.at[index, 'image_id']]
    data = data.to(device)
    prediction = name_dict[int(torch.argmax(model(data)))]
    test_csv.at[index, 'label'] = prediction

print(test_csv)
```

```
     image_id label
0           0    MC
1           1  LGSC
2           2  LGSC
3           3    EC
4           4  HGSC
..        ...   ...
103       103  HGSC
104       104    MC
105       105  HGSC
106       106    EC
107       107    EC

[108 rows x 2 columns]
```

In [ ]:
```
test_csv.to_csv('test.csv', index=False)
```