In [ ]:
```python
import os

small_dataset = ['CNV', 'DME', 'DRUSEN', 'NORMAL']
small_dataset_dir = '/lambda/nfs/main-filesystem/OCT_by_class' ## change this based on your own google dri
#small_dataset_dir = '/content/drive/MyDrive/Third Year/Summer/APS360/APS360 Project - Group 7/Code/small_d
#small_dataset_dir = '/content/drive/MyDrive/APS360 Project - Group 7/Code/small_dataset'
```

In [ ]:
```python
def num_images(dir, folders):
    print(f"Number of images in each folder:")
    for folder in folders:
        path = os.path.join(dir, folder)
        if os.path.isdir(path):
            num_files = len(os.listdir(path))
            print(f"{folder}: {num_files}")
        else:
            print(f"Folder '{folder}' does not exist in the dataset directory.")
```

In [ ]:
```python
num_images(small_dataset_dir, small_dataset)
```

```
Number of images in each folder:
CNV: 3000
DME: 3000
DRUSEN: 3000
NORMAL: 3000
```

In [ ]:
```python
import numpy as np
import torch

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
```

In [ ]:
```python
from torchvision import models, transforms, datasets
from torch import nn

resnet_model = models.resnet152(pretrained=True)
resnet_model = nn.Sequential(*list(resnet_model.children())[:-1]) # remove last classification layers
resnet_model.to(device)
resnet_model.eval()
```

In [ ]:

```python
from PIL import Image
import cv2
import numpy as np
import torch

def local_binary_pattern(image, P, R): # manual LBP function because LBP package from scikit-learn was not
    height, width = image.shape
    lbp = np.zeros_like(image, dtype=np.uint8)

    for i in range(R, height - R):
        for j in range(R, width - R):
            center_pixel = image[i, j]
            binary_code = []

            for p in range(P):
                theta = 2 * np.pi * p / P
                x = int(i + R * np.cos(theta))
                y = int(j - R * np.sin(theta))

                if image[x, y] >= center_pixel:
                    binary_code.append(1)
                else:
                    binary_code.append(0)

            lbp[i, j] = sum([binary_code[k] * (2**k) for k in range(len(binary_code))])

    return lbp

def extract_texture_and_edges(image_path):
    img = cv2.imread(image_path, cv2.IMREAD_GRAYSCALE)

    # edge detection using Sobel filter, https://how.dev/answers/sobel-operator-in-digital-image-processing
    sobel_x = cv2.Sobel(img, cv2.CV_64F, 1, 0, ksize=3)  # Sobel in x-direction
    sobel_y = cv2.Sobel(img, cv2.CV_64F, 0, 1, ksize=3)  # Sobel in y-direction
    edges = np.hypot(sobel_x, sobel_y)  # combine gradients

    # https://scikit-image.org/docs/0.25.x/auto_examples/features_detection/plot_local_binary_pattern.html
    lbp = local_binary_pattern(img, P=8, R=1)  # texture descriptors using Uniform Local Binary Pattern (LI

    edges_flat = edges.flatten()
    lbp_flat = lbp.flatten()
```

```
    combined_features = np.concatenate((edges_flat, lbp_flat), axis=0) # combine all features
    return combined_features

def extract_features(image_path, model, transform, device):
    image = Image.open(image_path).convert('RGB') # convert to rgb because resnet works with rgb
    image = transform(image).unsqueeze(0)
    image = image.to(device)

    with torch.no_grad():
        features = model(image)  # extract features from resnet
        features = features.view(features.size(0), -1)  # flatten to vector
    return features.cpu().numpy() # convert to numpy for svm


def extract_combined_features(image_path, resnet_model, transform, device):
    resnet_features = extract_features(image_path, resnet_model, transform)
    texture_edge_features = extract_texture_and_edges(image_path)

    # combine features (flatten resnet + texture/edge)
    combined_features = np.concatenate((resnet_features.flatten(), texture_edge_features), axis=0)
    return combined_features
```

In [ ]:

```
data_transform = transforms.Compose([
    transforms.Resize((224, 224)),
    transforms.ToTensor(),
    transforms.Normalize(mean=[0.485, 0.456, 0.406], std=[0.229, 0.224, 0.225]) # normalization for resnet
])

dataset = datasets.ImageFolder(small_dataset_dir, transform=data_transform)
```

In [ ]:

```
import os
import torch
import numpy as np
from tqdm import tqdm

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")

features = []
labels = []
```

```python
# extract features in batches to save RAM
batch_size = 256
diseases = os.listdir(small_dataset_dir)

for disease in diseases:
    disease_dir = os.path.join(small_dataset_dir, disease)

    image_paths = [
        os.path.join(disease_dir, img) for img in os.listdir(disease_dir)
        if os.path.isfile(os.path.join(disease_dir, img))
    ]

    for i in tqdm(range(0, len(image_paths), batch_size), desc=f"Processing {disease} Images", leave=False
        batch_paths = image_paths[i:i+batch_size]

        batch_features = []
        batch_labels = []

        for image_path in batch_paths:
            resnet_feature = extract_features(image_path, resnet_model, data_transform, device)
            texture_edge_feature = extract_texture_and_edges(image_path)

            combined_features = np.concatenate((resnet_feature.flatten(), texture_edge_feature), axis=0)
            batch_features.append(combined_features)
            batch_labels.append(disease)

        features.extend(batch_features)
        labels.extend(batch_labels)

        torch.cuda.empty_cache()

features = np.array(features)
labels = np.array(labels)
```

In [ ]:

```python
from sklearn.svm import SVC
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report, roc_curve, auc
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import StandardScaler
```

```python
from sklearn.decomposition import PCA
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(features, labels, test_size=0.3, random_state=42) # sp

scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)
```

In [ ]:
```python
pca = PCA(n_components=20)
X_train_pca = pca.fit_transform(X_train_scaled)
X_test_pca = pca.transform(X_test_scaled)
```

In [ ]:
```python
svm_rbf = SVC(kernel='rbf', C=10, gamma='scale', class_weight='balanced')  # rbf based on proposal
```

In [ ]:
```python
svm_rbf.fit(X_train_pca, y_train)# train SVM
```

Out[ ]:
```
▾ SVC
▶ Parameters
```

In [ ]:
```python
y_pred = svm_rbf.predict(X_test_pca)
```

In [ ]:
```python
# accuracy test

accuracy = accuracy_score(y_test, y_pred)
print(f"Accuracy: {accuracy:.4f}")
```

```
Accuracy: 0.5436
```

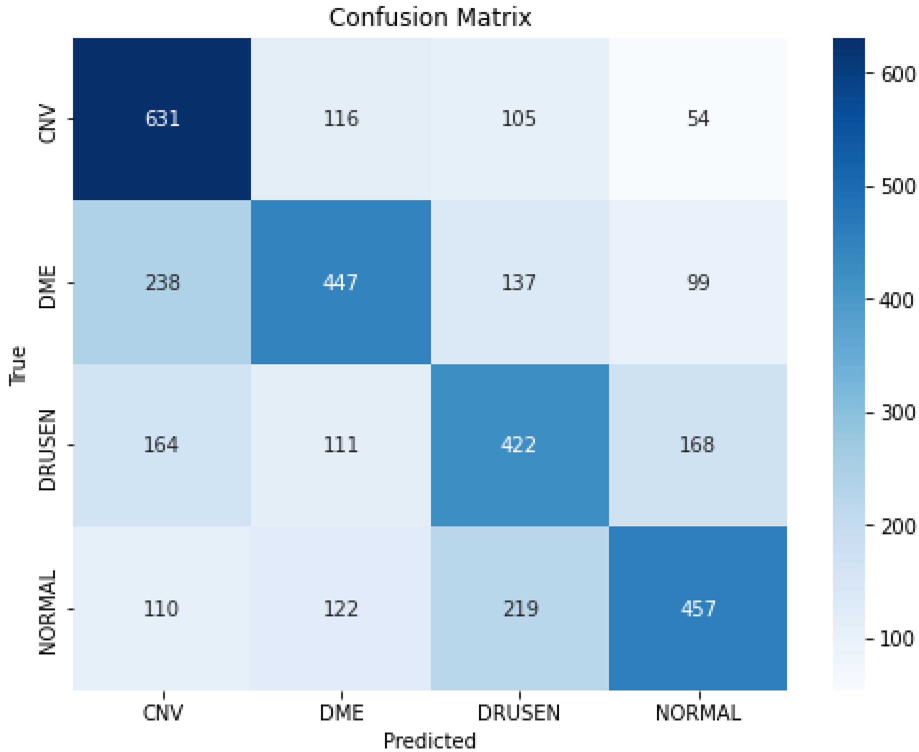
In [ ]:
```python
# confusion matrix test

cm = confusion_matrix(y_test, y_pred)
print(f"Confusion Matrix:\n{cm}")

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues', xticklabels=diseases, yticklabels=diseases)
plt.xlabel('Predicted')
plt.ylabel('True')
```

```python
plt.title('Confusion Matrix')
plt.show()
```

```
Confusion Matrix:
[[631 116 105  54]
 [238 447 137  99]
 [164 111 422 168]
 [110 122 219 457]]
```



In [ ]:
```python
report = classification_report(y_test, y_pred, target_names=diseases)
print(f"Classification Report:\n{report}")
```

Classification Report:

	precision	recall	f1-score	support
CNV	0.55	0.70	0.62	906
DME	0.56	0.49	0.52	921
DRUSEN	0.48	0.49	0.48	865
NORMAL	0.59	0.50	0.54	908
accuracy			0.54	3600
macro avg	0.54	0.54	0.54	3600
weighted avg	0.55	0.54	0.54	3600