In [ ]:
```python
import requests
from PIL import Image
import io
# import tensorflow as tf
import torch
import datetime
from pathlib import Path
from datasets import DatasetDict
from datasets import Dataset
from datasets import load_from_disk
import time
from tqdm import tqdm
```

In [ ]:
```python
from datasets import load_dataset

# this line is just for quick testin
# dataset = load_dataset("stochastic/random_streetview_images_pano_v0.0.2", split="train[:5000]")
dataset = load_dataset("stochastic/random_streetview_images_pano_v0.0.2", split="train")
```

In [ ]:
```python
# filter all the countries with not many images out of the dataset
passes = ['HK', 'HU', 'AU', 'SK', 'FR', 'FI', 'ZA', 'LT', 'PE', 'US']  # 10 most common

# Function to apply the filter
def filter_countries(example):
    return example['country_iso_alpha2'] in passes

# Apply the filter to the dataset
dataset = dataset.filter(filter_countries)
```

```
Filter: 100%|██████████| 11054/11054 [07:44<00:00, 23.81 examples/s]
```

In [ ]:
```python
# test out the filtering
dataset
```

Out[ ]:
```
Dataset({
    features: ['image', 'country_iso_alpha2', 'latitude', 'longitude', 'address'],
    num_rows: 2151
})
```

In [ ]:
```python
# preprocessing - this took 6min 48 seconds on my computer... jk 12 min second time
from torchvision.transforms import v2
import torchvision.transforms as transforms
```

```python
# data preprocessing
image_transforms = v2.Compose([
    v2.CenterCrop((561, 1010)),  # crops the middle image from the panorama
    v2.Resize((224, 224)),  # resizing the image to 224x224 for easier processing
    transforms.ToTensor()  # converting the image to a tensor
])

def transform(batch):
    # Transform each image in the batch and ensure it has 3 channels
    batch["image"] = [image_transforms(image.convert("RGB")) for image in batch["image"]]
    del batch["latitude"]
    del batch["longitude"]
    del batch["address"]
    return batch

# Apply the transformations to the dataset
dataset = dataset.map(transform, batched=True, batch_size=8)
```

```
Map: 100%|██████████| 2151/2151 [01:34<00:00, 22.75 examples/s]
```

In [ ]:
```python
# check what the name of the country thing is
# print(dataset[0])
```

In [ ]:
```python
# Make split and save
train_testvalid = dataset.train_test_split(test_size=0.4)
test_valid = train_testvalid['test'].train_test_split(test_size=0.5)

datasets = DatasetDict({
    'train': train_testvalid['train'],
    'test': test_valid['test'],
    'valid': test_valid['train']
})
datasets.save_to_disk("./data")
```

```
Saving the dataset (0/2 shards):   0%|          | 0/1290 [00:00<?, ? examples/s]
Saving the dataset (2/2 shards): 100%|██████████| 1290/1290 [00:03<00:00, 405.90 examples/s]
Saving the dataset (1/1 shards): 100%|██████████| 431/431 [00:04<00:00, 98.55 examples/s]
Saving the dataset (1/1 shards): 100%|██████████| 430/430 [00:04<00:00, 86.71 examples/s]
```

In [ ]:
```python
# country_codes = ["ZA","KR","AR","BW","GR","SK","HK","NL","PE","AU","KH","LT","NZ","RO","MY","SG","AE","FR","ES","IT",
country_codes = ['HK', 'HU', 'AU', 'SK', 'FR', 'FI', 'ZA', 'LT', 'PE', 'US']
country_dict = {}
# TODO: these might need to be tensor arrays but thats easy enough to change if needed
for i in range(len(country_codes)):
```

```
    country_dict[country_codes[i]] = [0.]*len(country_codes)
    country_dict[country_codes[i]][i] = 1.
# print(country_dict)
country_dict_not_one_hot = {}
for i in range(len(country_codes)):
    country_dict_not_one_hot[country_codes[i]] = i
```

In [ ]:

```
# referenced: https://blog.paperspace.com/convolutional-autoencoder/
# autoencoder classes (CREDIT: LARGELY TAKEN FROM 6_AUTOENCODER NOTEBOOK, but encoder and decoder architectures modifie
# should only have Encoder that has a latent dimension of 50 - corresponding to country weights
import torch.nn as nn
import torch.nn.functional as F

class MLPEncoder(torch.nn.Module):

    def __init__(self,
                 number_of_hidden_layers: int,
                 latent_size: int,
                 hidden_size: int,
                 input_size: int,
                 activation: torch.nn.Module):

        super().__init__()

        self.latent_size = latent_size
        assert number_of_hidden_layers >= 0, "Decoder number_of_hidden_layers must be at least 0"

        # Convolutional layers
        self.conv1 = nn.Conv2d(in_channels=3, out_channels=16, kernel_size=3, stride=2, padding=1)
        self.conv2 = nn.Conv2d(in_channels=16, out_channels=32, kernel_size=3, stride=2, padding=1)
        self.conv3 = nn.Conv2d(in_channels=32, out_channels=64, kernel_size=3, stride=2, padding=1)
        self.conv4 = nn.Conv2d(in_channels=64, out_channels=128, kernel_size=3, stride=2, padding=1)

        self.feature_map_size = 128 * 14 * 14

        # Fully connected layer to produce the latent representation of size 55
        self.fc = nn.Linear(self.feature_map_size, latent_size)

    def forward(self, x):
        x = F.relu(self.conv1(x))
        x = F.relu(self.conv2(x))
        x = F.relu(self.conv3(x))
        x = F.relu(self.conv4(x))
        x = x.view(-1, self.feature_map_size)  # Flatten the output
```

```
        x = self.fc(x)
        return x
```

In [ ]:
```
# define our training parameters and model
hidden_layers = 4
hidden_size = 30
latent_size = 10
input_size = 224
lr = 0.005
lamb = 1

# fix random seed
torch.manual_seed(0)

# select device
device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
model = MLPEncoder( number_of_hidden_layers=hidden_layers,
                latent_size=latent_size,
                hidden_size=hidden_size,
                input_size=input_size,
                activation=torch.nn.ReLU()).to(device)

# use an optimizer to handle parameter updates
opt = torch.optim.Adam(model.parameters(), lr=lr, weight_decay=1e-5)

# save all log data to a local directory
run_dir = "logs"

# to clear out TensorBoard and start totally fresh, we'll need to
# remove old logs by deleting them from the directory
!rm -rf ./logs/

# timestamp the logs for each run so we can sort through them
run_time = datetime.datetime.now().strftime("%I%M%p on %B %d, %Y")

# initialize a SummaryWriter object to handle all logging actions
from torch.utils.tensorboard import SummaryWriter
logger = SummaryWriter(log_dir=Path(run_dir) / run_time, flush_secs=20)
```

In [ ]:
```
# model(data['train'][0]['image'].to(device)).shape
```

In [ ]:
```
# load data from disk
data = load_from_disk("./data")
data = data.with_format("torch")
```

In [ ]:
```
# test the datatype of the dataset - the datasets['train']['image'] should be a tensor
# type(datasets['train'][0]['image'])
# datasets['train'][0]['image']

torch.tensor(data['train'][0]['image']).shape
# print(len(datasets['train'][0]['image'][0]))
# print(len(datasets['train'][0]['image'][0][0]))
```

```
/var/folders/vc/7kh7f0_n749bhl6c8b17t3q40000gn/T/ipykernel_16242/3299156962.py:5: UserWarning: To copy construct from a tensor, it is recommended to use sourceTensor.clone().detach() or sourceTensor.clone().detach().requires_grad_(True), rather than torch.tensor(sourceTensor).
  torch.tensor(data['train'][0]['image']).shape
```

Out[ ]:
```
torch.Size([3, 224, 224])
```

In [ ]:
```
# (***credit***: mostly taken from provided notebook )
# training
torch.autograd.set_detect_anomaly(False)

epochs = 25
batch_size = 1000
start_time = time.time()
loss_history = []
valid_history = []
acc_history = []
valid_acc_history = []
report_every = 1
# Loss = torch.nn.BCELoss()
Loss = torch.nn.CrossEntropyLoss()

train_loader = torch.utils.data.DataLoader(data['test'], batch_size=batch_size, shuffle=True)
valid_loader = torch.utils.data.DataLoader(data['valid'], batch_size=batch_size, shuffle=True)


for epoch in range(epochs):
    model.train()
    # weight batch losses/scores proportional to batch size
    iter_count = 0
    valid_iter_count = 0
    loss_epoch = 0.
    class_accuracy_epoch = 0.
    valid_loss_epoch = 0.
    valid_accuracy_epoch = 0.
    ###
    ### IMAGE_DATA_TRAIN is training data, shape is 610 x 3 x 64 x 64
```

```
 ###

# print(batched_image_data_train[0][0].shape)
 #batched_image_data_train = [batched_image_data_train[0][0].unsqueeze(0)]
 for idx, batch in enumerate(train_loader):

     x = batch['image']
     x = torch.tensor(x)
     # print(x)
     # flatten input images and move to device\
     # *****
     # x = x / 255
     # plot x_real later to see if this is correct
     x = x.to(device)
     model.zero_grad()
     opt.zero_grad()

     # train on a batch of inputs
     pred_labels = model(x)
     # print(pred_labels)

     # get the true label
     # label = torch.tensor(country_dict[img['country_iso_alpha2']], dtype=torch.float).to(device).unsqueeze(0)
     # print(batch['country_iso_alpha2'])
     labels = torch.tensor([country_dict_not_one_hot[country] for country in batch['country_iso_alpha2']]).to(device
     # print(labels)
     # print(len(country_dict))
     # pred labels is 4x56
     # print(len(pred_labels))
     # print(len(pred_labels[0]))
     # label is 1x56

     loss = Loss(pred_labels, labels)
     loss.backward()
     torch.nn.utils.clip_grad_norm_(model.parameters(), max_norm=1.0)
     opt.step()

     # log loss
     loss_epoch += loss.detach().item()

     # classification accuracy
     # add 1 to class_accuracy_epoch if the classification is correct, else 0
     # find index of max probability from pred_labels
     for i in range(len(pred_labels)):
         c = torch.argmax(pred_labels[i])
```

```
            # find index of 1 from label
            true_class = torch.argmax(labels[i])
            acc = (true_class == c)
            class_accuracy_epoch += acc
            iter_count += 1
        c = torch.argmax(pred_labels)

        # print(f"true: {true_class}")
        # print(f"pred: {classification.mean()}")
        # print(f"acc: {acc}")

        # plot loss
        class_accuracy_epoch /= iter_count #accuracy as a percent
    # print(iter_count)
        # logger.add_scalar("mse_loss", loss_epoch, epoch)
        loss_history.append(loss_epoch)
        acc_history.append(class_accuracy_epoch)


                # logger.add_scalar("mse_loss_valid", valid_loss_epoch, epoch)
        # # plot example generated images
        # with torch.no_grad():
        #     reconstructed_batch = model(example_batch.reshape(batch_size, -1)).reshape(batch_size, 1, image_size, ima
        #     logger.add_image("reconstructed_images", make_grid(reconstructed_batch, math.floor(math.sqrt(batch_size))
            # calculate validation loss

        with torch.no_grad():
            model.eval()
            for idx, valid_data in enumerate(valid_loader):
                x_valid = torch.tensor(valid_data['image']) #.float()
                # x_valid = x_valid / 255
                x_valid = x_valid.to(device)
                # print(x_valid)
                pred_labels = model(x_valid)

                labels_valid = torch.tensor([country_dict_not_one_hot[country] for country in valid_data['country_iso_a
                # print(label_valid)
                # print(pred_labels)
                valid_loss = Loss(pred_labels, labels_valid)
                valid_loss_epoch += valid_loss.detach().item()


                # classification accuracy
                # add 1 to class_accuracy_epoch if the classification is correct, else 0
                for i in range(len(pred_labels)):
```

```
                    c = torch.argmax(pred_labels[i])
                    # find index of 1 from label
                    true_class = torch.argmax(labels_valid[i])
                    acc = (true_class == c)
                    valid_accuracy_epoch += acc
                    valid_iter_count += 1
                # print(f"true: {true_class}")
                # print(f"pred: {classification.mean()}")
                # print(f"acc: {valid_acc}")
            valid_loss_epoch
            valid_history.append(valid_loss_epoch)
            valid_accuracy_epoch /= valid_iter_count
            valid_acc_history.append(valid_accuracy_epoch)

    if (epoch + 1) % report_every == 0:
        mins = (time.time() - start_time) / 60
        print(f"Epoch: {epoch + 1:5d}\tMSE Loss: {loss_epoch :6.4f}\t in {mins:5.1f}min")
        print()
```

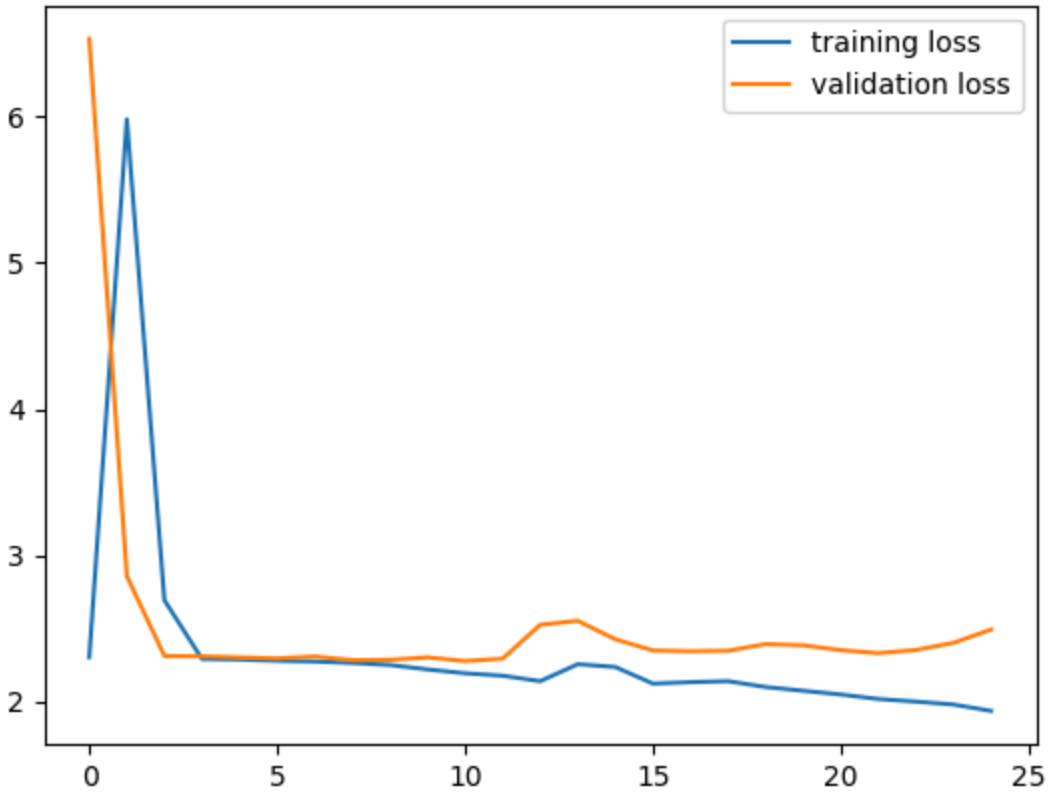
```
/var/folders/vc/7kh7f0_n749bhl6c8b17t3q40000gn/T/ipykernel_16242/227957138.py:38: UserWarning: To copy construct from a tensor, it is recommended to use sourceTensor.clone().detach() or sourceTensor.clone().detach().requires_grad_(True), rather than torch.tensor(sourceTensor).
  x = torch.tensor(x)
/var/folders/vc/7kh7f0_n749bhl6c8b17t3q40000gn/T/ipykernel_16242/227957138.py:105: UserWarning: To copy construct from a tensor, it is recommended to use sourceTensor.clone().detach() or sourceTensor.clone().detach().requires_grad_(True), rather than torch.tensor(sourceTensor).
  x_valid = torch.tensor(valid_data['image']) #.float()
```

```
Epoch:     1    MSE Loss: 2.3009         in   0.6min
Epoch:     2    MSE Loss: 5.9839         in   1.3min
Epoch:     3    MSE Loss: 2.6905         in   1.7min
Epoch:     4    MSE Loss: 2.2884         in   2.2min
Epoch:     5    MSE Loss: 2.2844         in   2.6min
Epoch:     6    MSE Loss: 2.2758         in   3.0min
Epoch:     7    MSE Loss: 2.2711         in   3.5min
Epoch:     8    MSE Loss: 2.2611         in   4.0min
Epoch:     9    MSE Loss: 2.2473         in   4.5min
Epoch:    10    MSE Loss: 2.2168         in   4.9min
Epoch:    11    MSE Loss: 2.1905         in   5.3min
Epoch:    12    MSE Loss: 2.1737         in   5.7min
Epoch:    13    MSE Loss: 2.1363         in   6.2min
Epoch:    14    MSE Loss: 2.2527         in   6.6min
Epoch:    15    MSE Loss: 2.2335         in   7.0min
Epoch:    16    MSE Loss: 2.1195         in   7.5min
Epoch:    17    MSE Loss: 2.1297         in   7.9min
Epoch:    18    MSE Loss: 2.1363         in   8.3min
Epoch:    19    MSE Loss: 2.0965         in   8.8min
Epoch:    20    MSE Loss: 2.0707         in   9.2min
Epoch:    21    MSE Loss: 2.0451         in   9.6min
Epoch:    22    MSE Loss: 2.0142         in  10.0min
Epoch:    23    MSE Loss: 1.9965         in  10.4min
```

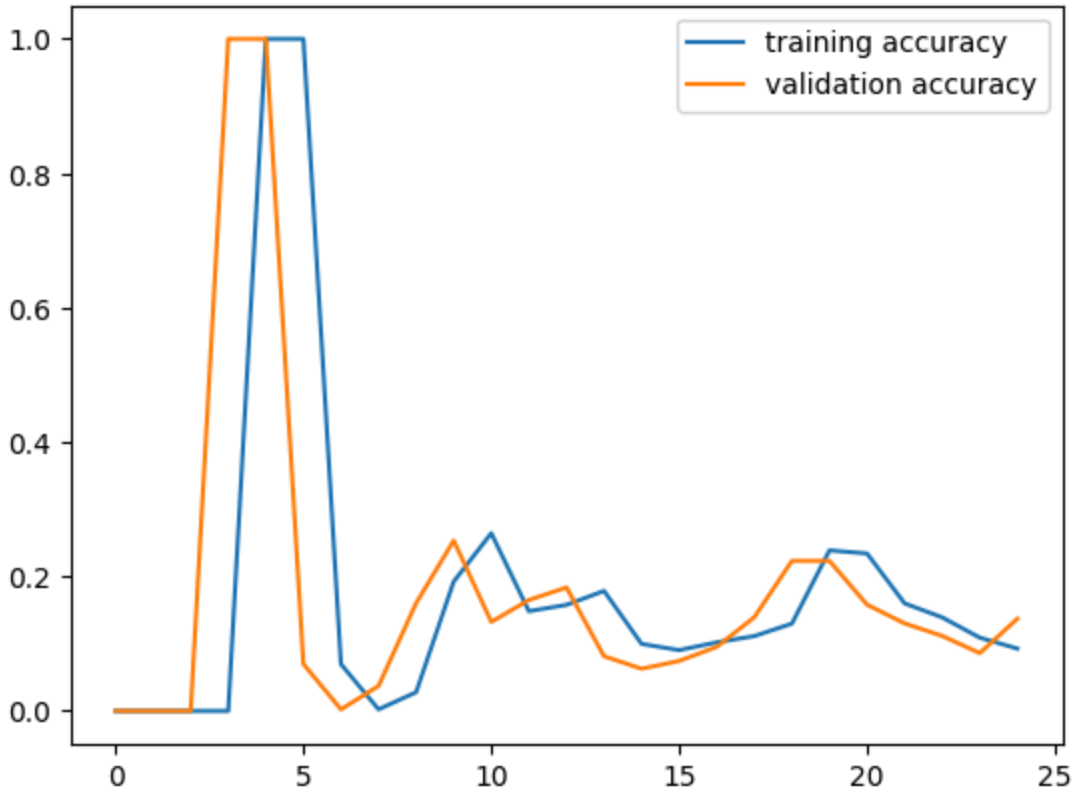
```
Epoch:    24    MSE Loss: 1.9765         in  10.8min

Epoch:    25    MSE Loss: 1.9325         in  11.3min
```

In [ ]:
```python
# plot loss history
import matplotlib.pyplot as plt
plt.plot(loss_history, label="training loss")
plt.plot(valid_history, label="validation loss")
plt.legend()
plt.show()
```



In [ ]:
```python
# plot accuracy history
plt.plot(acc_history, label="training accuracy")
plt.plot(valid_acc_history, label="validation accuracy")
plt.legend()
plt.show()
```



In [ ]:
```
def predict(i):
    prediction = model(data['train'][i]['image'].to(device))
    country = torch.argmax(prediction)
    return country_codes[country]
```

In [ ]:
```
from collections import Counter
Counter([predict(i) for i in range(100)])
```

Out[ ]:
```
Counter({'LT': 28,
         'HU': 17,
         'HK': 17,
         'US': 11,
         'AU': 9,
         'FR': 9,
         'ZA': 4,
         'SK': 3,
         'FI': 2})
```

In [ ]:
```
# find most common countries in dataset
from collections import Counter
```

```
country_counts = Counter(data['test']['country_iso_alpha2'])
print(country_counts.most_common(10))
```

```
[('HU', 54), ('HK', 51), ('LT', 51), ('AU', 47), ('FR', 44), ('US', 42), ('SK', 41), ('ZA', 39), ('PE', 39), ('FI', 2
3)]
```

In [ ]: