In [1]:

```
import torch
from torch.utils.data import Dataset
import torchvision.transforms as transforms
import os
from PIL import Image
from torch.utils.data import DataLoader
import matplotlib.pyplot as plt
import numpy as np
import torch.nn as nn
import torch.optim as optim
from torch.optim import lr_scheduler
import time
import glob
import yaml
import torchvision
```

In [2]:

```
def set_seed(seed):
    torch.manual_seed(seed)
    np.random.seed(seed)

    # for cuda
    torch.cuda.manual_seed_all(seed)
    torch.backends.cudnn.deterministic = True
```

In [3]:

```
set_seed(0)
```

In [4]:

```
def extract_files():
    import google.colab
    import zipfile

    google.colab.drive.mount('/content/drive')
    PROJECT_DIR = "/content/drive/MyDrive/thesis/data/"

    zip_ref = zipfile.ZipFile(PROJECT_DIR + "fiveK.zip", 'r')
    zip_ref.extractall(".")
    zip_ref.close()
```

In [5]:

```
if 'google.colab' in str(get_ipython()):
  extract_files()
  config_path = "/content/drive/MyDrive/thesis/config.yaml"
else:
  config_path = "../../config.yaml"
```

```
Mounted at /content/drive
```

In [6]:

```
device = torch.device('cuda:0' if torch.cuda.is_available() else 'cpu')
print(device)
```

```
cuda:0
```

In [7]:

```
# List of class directories
class_directories = ['expA', 'expB', 'expC', 'expD', 'expE']
# raw data directory
raw_dir = "raw"
```

In [8]:

```
class CustomDataset(Dataset):
    def __init__(self, data_dir, raw_data_dir, filename, transform=None):
        super().__init__()
        self.filename = filename
        self.transform = transform

        self.classname = self._extract_class_name(data_dir)
        self.encode = {k: i for i, k in enumerate(class_directories)}


        # Read the train.txt file and store the image paths
        with open(self.filename) as f:
            img_paths= []
            raw_img_paths = []
            for line in f:
                line = line.strip()
                img_paths.append(os.path.join(data_dir, line))
                raw_img_paths.append(os.path.join(raw_data_dir, line))

            self.image_paths = img_paths
            self.raw_image_paths = raw_img_paths

    def __len__(self):
        return len(self.image_paths)

    def __getitem__(self, index):
        image_path = self.image_paths[index]
        raw_image_path = self.raw_image_paths[index]
        image = Image.open(image_path)
        raw_image = Image.open(raw_image_path)
        image = np.dstack((np.array(image), np.array(raw_image)))
        label = self.encode[self.classname]
        if self.transform is not None:
            image = self.transform(image)
        return image, label

    def _extract_class_name(self, root_dir):
        # Extract the class name from the root directory
        class_name = os.path.basename(root_dir)
        return class_name
```

In [9]:

```
try:
    # Load configuration
    with open(config_path, 'r') as config_file:
        config = yaml.safe_load(config_file)
except:
    raise FileNotFoundError(f"Config file not found at path: {config_path}")
```

In [10]:

```
data_folder = config['paths']['data']
train_file = config['paths']['train']
```

In [11]:

```
def read_dataset(data_folder, txt_file, trasform=None):
    # Create separate datasets for each class
    datasets = []

    for class_dir in class_directories:
        class_train_dataset = CustomDataset(
            data_dir=os.path.join(data_folder, class_dir),
            raw_data_dir=os.path.join(data_folder, raw_dir),
            filename=os.path.join(txt_file),
            transform=trasform
        )
        datasets.append(class_train_dataset)
    return datasets
```

In [12]:

```
training_tr = transforms.Compose([
        transforms.ToTensor(),
        transforms.RandomResizedCrop(160, antialias=True),
        transforms.RandomHorizontalFlip(),
        transforms.Normalize([0.4397, 0.4234, 0.3911, 0.2279, 0.2017, 0.1825], [0.2306, 0.2201, 0.2327, 0.1191, 0.1092, 0.1088])
    ])
```

In [13]:

```
# Combine datasets if needed (e.g., for training)
train_dataset = torch.utils.data.ConcatDataset(read_dataset(data_folder, train_file, training_tr))
```

In [14]:

```
bs = 128
```

In [15]:

```
train_dataloader = DataLoader(train_dataset, batch_size=bs, shuffle=True)
```

In [16]:

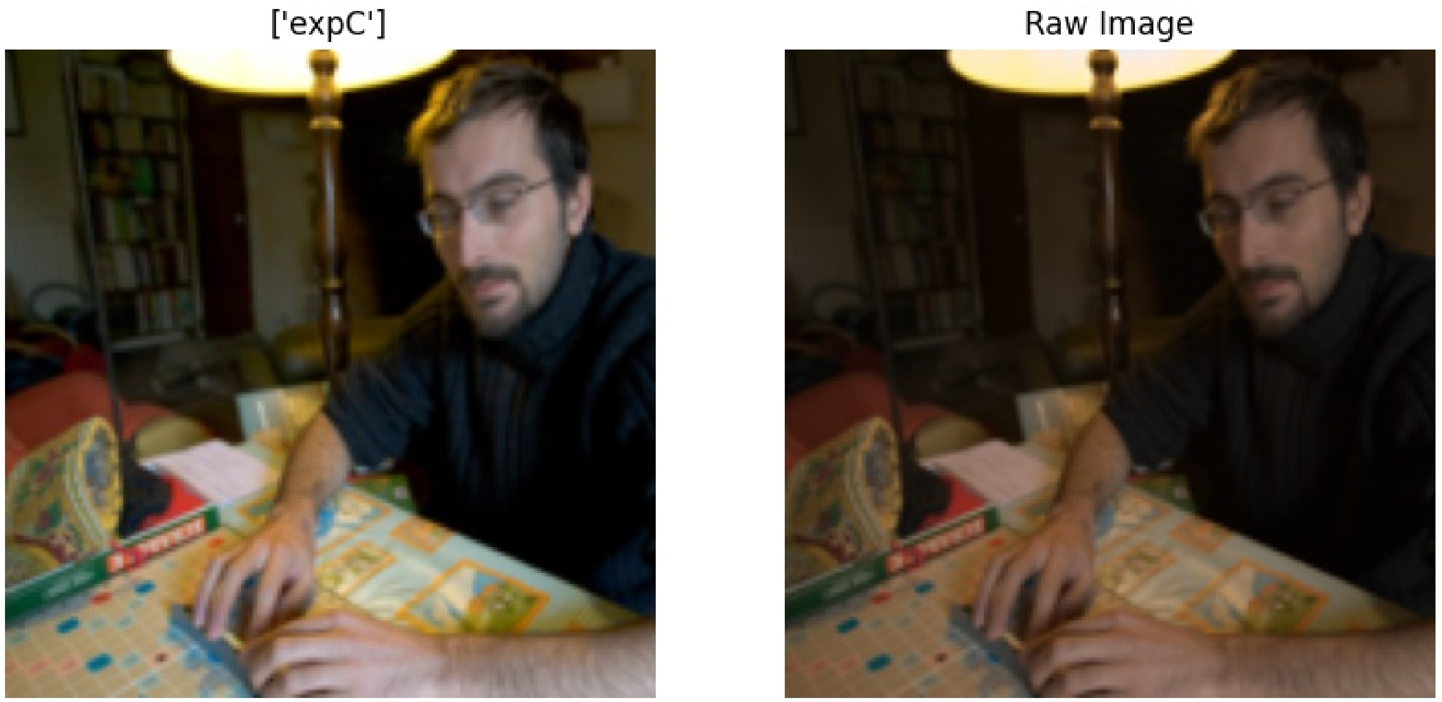
```
train_features, train_labels = next(iter(train_dataloader))
```

In [17]:

```
def imshow(inp, title=None):
    """Display image for Tensor."""
    inp = inp.numpy().transpose((1, 2, 0))
    org_img = inp[:, :, :3]
    raw_img = inp[:, :, 3:]
    mean1 = np.array([0.4397, 0.4234, 0.3911])
    mean2 = np.array([0.2279, 0.2017, 0.1825])
    std1 = np.array([0.2306, 0.2201, 0.2327])
    std2 = np.array([0.1191, 0.1092, 0.1088])
    org_img = std1 * org_img + mean1
    raw_img = std2 * raw_img + mean2
    org_img = np.clip(org_img, 0, 1)
    raw_img = np.clip(raw_img, 0, 1)

    # Create a figure with two subplots
    _, axes = plt.subplots(1, 2, figsize=(10, 5))

    # Plot original image on the first subplot
    axes[0].imshow(org_img)
    if title is not None:
        axes[0].set_title(title)
    axes[0].axis('off')

    # Plot raw image on the second subplot
    axes[1].imshow(raw_img)
    axes[1].set_title('Raw Image')
    axes[1].axis('off')

    plt.pause(0.001)  # pause a bit so that plots are updated
    plt.show()
```

In [18]:

```
# Get a batch of training data
inputs, labels = next(iter(train_dataloader))
out = inputs[:1].squeeze()

imshow(out, title=[class_directories[x] for x in labels[:1]])
```



In [19]:

```
print(len(train_dataset))
```

```
20000
```

In [20]:

```
base_checkpoint_path = config['paths']['checkpoints']
# Create the directory if it does not exist
if not os.path.exists(base_checkpoint_path):
    os.makedirs(base_checkpoint_path)
```

In [21]:

```
def get_lr(optimizer):
    for param_group in optimizer.param_groups:
        return param_group['lr']
```

In [22]:

```
def train_model(model, criterion, optimizer, scheduler, current_epoch, num_epochs=25):
    since = time.time()
    best_acc = 0.0
    model.train()
    for epoch in range(current_epoch, num_epochs):
            # formatted string to append epoch number to checkpoint filename
        print(f'Epoch {epoch + 1}/{num_epochs}')
        print('-' * 10)
        running_loss = 0.0
        running_corrects = 0
        # Iterate over data.
        for inputs, labels in train_dataloader:
            inputs = inputs.to(device)
            labels = labels.to(device)

            # zero the parameter gradients
            optimizer.zero_grad()
            outputs = model(inputs)
            _, preds = torch.max(outputs, 1)
            loss = criterion(outputs, labels)
            loss.backward()
            optimizer.step()

            # statistics
            running_loss += loss.item() * inputs.size(0)
            running_corrects += torch.sum(preds == labels.data)

        scheduler.step()

        epoch_loss = running_loss / len(train_dataset)
        epoch_acc = running_corrects.double() / len(train_dataset)

        print(f'Loss: {epoch_loss:.4f} Acc: {epoch_acc:.4f} LR: {get_lr(optimizer):.8f}')
        print()

        PATH = os.path.join(base_checkpoint_path, f'{os.path.basename(base_checkpoint_path)}_{epoch+1}.pth')
        # save checkpoint
        state = {
            'epoch': epoch + 1,
            'state_dict': model.state_dict(),
            'optimizer': optimizer.state_dict(),
            'loss': epoch_loss,
            'scheduler': scheduler.state_dict(),
            'accuracy': epoch_acc
        }
        # save the best model parameters
        torch.save(state, PATH)
        # deep copy the model
        if epoch_acc > best_acc:
            best_acc = epoch_acc

    time_elapsed = time.time() - since
    print(f'Training complete in {time_elapsed // 60:.0f}m {time_elapsed % 60:.0f}s')
    print(f'Best Acc: {best_acc:4f}')
```

In [23]:

```
model_name = config['model']['name']
if not model_name.startswith('resnet'):
    raise ValueError("Model name must start with 'resnet'")
```

In [24]:

```
if config['model']['type'] == 'FEATURE_EXTRACTOR':
    model = torchvision.models.__dict__[model_name](weights='IMAGENET1K_V1')
    # Freeze all layers except the fully connected layers
    for param in model.parameters():
        param.requires_grad = False
elif config['model']['type'] == 'FINE_TUNING':
    model = torchvision.models.__dict__[model_name](weights='IMAGENET1K_V1')
elif config['model']['type'] == 'TRAIN_FROM_SCRATCH':
    model = torchvision.models.__dict__[model_name](weights=None)
else:
    raise ValueError(f"Unknown model type: {config['model']['type']}")

# Parameters of newly constructed modules have requires_grad=True by default
num_ftrs = model.fc.in_features
model.fc =  nn.Linear(num_ftrs, config['model']['num_classes'])

# change the first convolution to accept 6 channels
model.conv1 = nn.Conv2d(6, 64, kernel_size=(7, 7), stride=(2, 2), padding=(3, 3), bias=False)

# move the model to GPU/CPU
model = model.to(device)

criterion = nn.CrossEntropyLoss()

optimizer = optim.SGD(model.parameters(), lr=config['model']['lr'], momentum=config['model']['momentum'])

milestones = [9, 18, 34, 50, 70]
```

```
# Decay LR by a factor of 0.1 every 7 epochs
scheduler = lr_scheduler.MultiStepLR(optimizer, milestones, gamma=0.1)
```

In [25]:

```
# load the last model saved if there is any
def load_latest_model(model, optimizer, scheduler, checkpoint_dir):
    # Check if the directory exists
    if not os.path.exists(base_checkpoint_path):
        print(f"No directory found: {checkpoint_dir}")
        return model, optimizer, scheduler, 0, None

    # Get a list of all checkpoint files in the directory
    checkpoint_files = glob.glob(os.path.join(checkpoint_dir, f'{os.path.basename(checkpoint_dir)}_*.pth'))
    print(checkpoint_files)
    # Check if any checkpoint files are present
    if not checkpoint_files:
        print(f"No checkpoints found in the directory: {checkpoint_dir}")
        return model, optimizer, scheduler, 0, None

    # Find the latest checkpoint file based on the epoch number in the filename
    latest_checkpoint = max(checkpoint_files, key=os.path.getctime)

    # Load the latest checkpoint
    checkpoint = torch.load(latest_checkpoint, map_location=torch.device(device))
    model.load_state_dict(checkpoint['state_dict'])
    optimizer.load_state_dict(checkpoint['optimizer'])
    scheduler.load_state_dict(checkpoint['scheduler'])
    epoch = checkpoint['epoch']
    loss = checkpoint['loss']
    print(checkpoint['accuracy'])

    print(f"Loaded model from checkpoint: {latest_checkpoint}")
    print(f"Resuming training from epoch {epoch}")

    return model, optimizer,scheduler, epoch, loss
```

In [26]:

```
model, optimizer, scheduler, current_epoch, loss = load_latest_model(model, optimizer, scheduler, base_checkpoint_path)
```

```
['/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_1.pth', '/content/drive/MyDrive/th
esis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_2.pth', '/content/drive/MyDrive/thesis/model/checkpoints/rese
tnet18_scratch_raw/resetnet18_scratch_raw_3.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet
18_scratch_raw_4.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_5.pth', '/co
ntent/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_6.pth', '/content/drive/MyDrive/thesis/
model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_7.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet1
8_scratch_raw/resetnet18_scratch_raw_8.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_sc
ratch_raw_9.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_10.pth', '/conten
el/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_12.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_
scratch_raw/resetnet18_scratch_raw_13.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scr
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t/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_26.pth', '/content/drive/MyDrive/thesis/mod
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scratch_raw/resetnet18_scratch_raw_28.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scr
atch_raw_29.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_30.pth', '/conten
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el/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_32.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_
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atch_raw_34.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_35.pth', '/conten
t/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_36.pth', '/content/drive/MyDrive/thesis/mod
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scratch_raw/resetnet18_scratch_raw_38.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scr
atch_raw_39.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_40.pth', '/conten
t/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_41.pth', '/content/drive/MyDrive/thesis/mod
el/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_42.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_
scratch_raw/resetnet18_scratch_raw_43.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scr
atch_raw_44.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_45.pth', '/conten
t/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_46.pth', '/content/drive/MyDrive/thesis/mod
el/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_47.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_
scratch_raw/resetnet18_scratch_raw_48.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scr
atch_raw_49.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_50.pth', '/conten
t/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_51.pth', '/content/drive/MyDrive/thesis/mod
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scratch_raw/resetnet18_scratch_raw_53.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scr
atch_raw_54.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_55.pth', '/conten
t/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_56.pth', '/content/drive/MyDrive/thesis/mod
el/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_57.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_
scratch_raw/resetnet18_scratch_raw_58.pth', '/content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scr
atch_raw_59.pth']
tensor(0.5854, device='cuda:0', dtype=torch.float64)
Loaded model from checkpoint: /content/drive/MyDrive/thesis/model/checkpoints/resetnet18_scratch_raw/resetnet18_scratch_raw_59.pth
Resuming training from epoch 59
```

In [27]:

```
print(get_lr(optimizer))
```

```
1.0000000000000002e-06
```

In [28]:

```
train_model(model, criterion, optimizer, scheduler,current_epoch, num_epochs=config['model']['num_epochs'])
```

```
Epoch 60/80
----------
Loss: 1.0411 Acc: 0.5855 LR: 0.00000100

Epoch 61/80
----------
Loss: 1.0397 Acc: 0.5851 LR: 0.00000100

Epoch 62/80
----------
Loss: 1.0372 Acc: 0.5859 LR: 0.00000100

Epoch 63/80
----------
Loss: 1.0385 Acc: 0.5843 LR: 0.00000100

Epoch 64/80
----------
Loss: 1.0359 Acc: 0.5886 LR: 0.00000100

Epoch 65/80
----------
Loss: 1.0344 Acc: 0.5875 LR: 0.00000100

Epoch 66/80
----------
Loss: 1.0256 Acc: 0.5928 LR: 0.00000100

Epoch 67/80
----------
Loss: 1.0250 Acc: 0.5972 LR: 0.00000100

Epoch 68/80
----------
Loss: 1.0186 Acc: 0.5957 LR: 0.00000100

Epoch 69/80
----------
Loss: 1.0362 Acc: 0.5881 LR: 0.00000100

Epoch 70/80
----------
Loss: 1.0335 Acc: 0.5924 LR: 0.00000010

Epoch 71/80
----------
Loss: 1.0329 Acc: 0.5873 LR: 0.00000010
```

```
Epoch 72/80
----------
Loss: 1.0322 Acc: 0.5932 LR: 0.00000010

Epoch 73/80
----------
Loss: 1.0295 Acc: 0.5894 LR: 0.00000010

Epoch 74/80
----------
Loss: 1.0395 Acc: 0.5830 LR: 0.00000010

Epoch 75/80
----------
Loss: 1.0300 Acc: 0.5927 LR: 0.00000010

Epoch 76/80
----------
Loss: 1.0335 Acc: 0.5883 LR: 0.00000010

Epoch 77/80
----------
Loss: 1.0364 Acc: 0.5873 LR: 0.00000010

Epoch 78/80
----------
Loss: 1.0414 Acc: 0.5852 LR: 0.00000010

Epoch 79/80
----------
Loss: 1.0443 Acc: 0.5854 LR: 0.00000010

Epoch 80/80
----------
Loss: 1.0371 Acc: 0.5871 LR: 0.00000010

Training complete in 78m 32s
Best Acc: 0.597150
```

In [ ]:

```
time.sleep(5)  # Sleep for 5 seconds to let the system cool down
from google.colab import runtime
runtime.unassign()
```