Transfer Learning

In [1]:
```python
import torch
import torch.nn as nn
import torch.optim as optim
from torch.optim import lr_scheduler
import numpy as np
from torchvision import datasets, models, transforms
import matplotlib.pyplot as plt
import time
import os
import copy

torch.cuda.empty_cache()
torch.manual_seed(0)     # for reproducibility
```

Out[1]:
```
<torch._C.Generator at 0x12b80292810>
```

Load Data

We will use torchvision and torch.utils.data packages for loading the data.

In [2]:
```python
# Data augmentation and normalization for training
# Just normalization for validation
data_transforms = {
    'train': transforms.Compose([
        transforms.Resize([224, 224]),
        transforms.ToTensor()
    ]),
    'val': transforms.Compose([
        transforms.Resize([224, 224]),
        transforms.ToTensor()
    ])
}

data_dir = 'D:\\data (augmented, 4 classes, tif)'
image_datasets = {x: datasets.ImageFolder(os.path.join(data_dir, x),
                                          data_transforms[x])
                  for x in ['train', 'val']}

batch_size = 128      # Need it as a global variable for computing average loss/accuracy per iterati
on
dataloaders = {x: torch.utils.data.DataLoader(image_datasets[x], batch_size=batch_size,
                                             shuffle=True, num_workers=4)
              for x in ['train', 'val']}
dataset_sizes = {x: len(image_datasets[x]) for x in ['train', 'val']}
class_names = image_datasets['train'].classes

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

Training the model

Now, let's write a general function to train a model. Here, we will illustrate:

- Scheduling the learning rate
- Saving the best model

In the following, parameter `scheduler` is an LR scheduler object from `torch.optim.lr_scheduler`.

In [3]:
```python
def train_model(model, criterion, optimizer, scheduler, num_epochs=25):
    since = time.time()

    best_model_wts = copy.deepcopy(model.state_dict())
    best_acc = 0.0

    epoch_numbers = []
    epoch_train_accuracies = []
    epoch_train_losses = []
    epoch_val_accuracies = []
    epoch_val_losses = []

    for epoch in range(num_epochs):
        epoch_numbers.append(epoch)            # for plotting
        print('Epoch {}/{}'.format(epoch, num_epochs - 1))
        print('-' * 10)

        # Each epoch has a training and validation phase
        for phase in ['train', 'val']:
            if phase == 'train':
                if scheduler != "":
                    scheduler.step()
                model.train()  # Set model to training mode
            else:
                model.eval()   # Set model to evaluate mode

            running_loss = 0.0
            running_corrects = 0

            # Iterate over data.
            for inputs, labels in dataloaders[phase]:      # The labels will correspond to the alpha
betical order of the class names (https://discuss.pytorch.org/t/how-to-get-the-class-names-to-class-
label-mapping/470).
                inputs = inputs.to(device)
                labels = labels.to(device)

                # zero the parameter gradients
                optimizer.zero_grad()

                # forward
                # track history if only in train
                with torch.set_grad_enabled(phase == 'train'):
                    outputs = model(inputs)
                    _, preds = torch.max(outputs, 1)
                    loss = criterion(outputs, labels)

                    # backward + optimize only if in training phase
                    if phase == 'train':
                        loss.backward()
                        optimizer.step()

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

            epoch_loss = running_loss/dataset_sizes[phase]
            epoch_acc = running_corrects.double()/dataset_sizes[phase]

            print('{} Loss: {:.4f} Acc: {:.4f}'.format(
                phase, epoch_loss, epoch_acc))

            # For plotting
            if phase == 'train':
                epoch_train_accuracies.append(epoch_acc)
                epoch_train_losses.append(epoch_loss)
            else:
                epoch_val_accuracies.append(epoch_acc)
                epoch_val_losses.append(epoch_loss)

            # deep copy the model
            if phase == 'val' and epoch_acc > best_acc:
                best_acc = epoch_acc
                best_model_wts = copy.deepcopy(model.state_dict())

        print()

    # Plotting

    plt.title("Training Curve (Loss)")
    plt.plot(epoch_numbers, epoch_train_losses, label="Train")
    plt.plot(epoch_numbers, epoch_val_losses, label="Validation")
    plt.xlabel("Epochs")
    plt.ylabel("Loss")
    plt.legend(loc='best')
    plt.show()

    plt.title("Training Curve (Accuracy)")
    plt.plot(epoch_numbers, epoch_train_accuracies, label="Train")
    plt.plot(epoch_numbers, epoch_val_accuracies, label="Validation")
    plt.xlabel("Epochs")
    plt.ylabel("Accuracy")
    plt.legend(loc='best')
    plt.show()

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

    # load best model weights
    model.load_state_dict(best_model_wts)
    return model
```

Finetuning the convnet

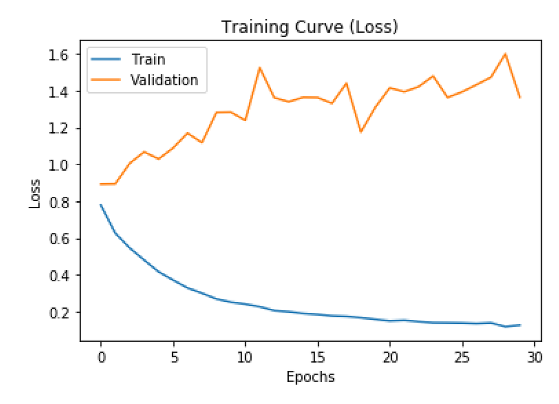
Load a pretrained model and reset final fully connected layer.

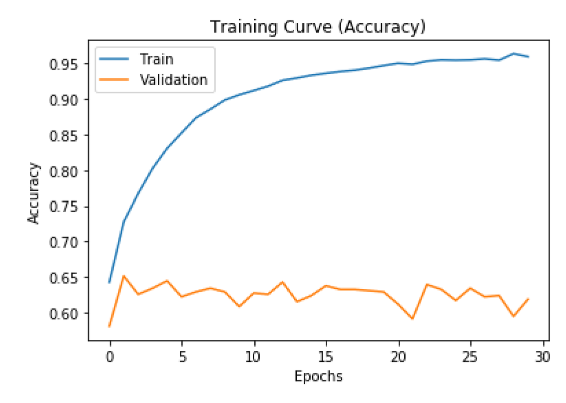
In [4]:
```python
model_ft = models.alexnet(pretrained=True)
model_ft.classifier[6] = nn.Linear(4096, len(class_names))
# model_ft.classifier.add_module("7", nn.Dropout())

model_ft = model_ft.to(device)

criterion = nn.CrossEntropyLoss()

optimizer_ft = optim.Adam([
                {'params': model_ft.features.parameters(), 'lr': 0.0001},        # The other (non-fi
nal) layers will have a lr = 0.1*base lr.
                {'params': model_ft.classifier[:6].parameters(), 'lr': 0.0001},
                {'params': model_ft.classifier[6:].parameters()}                  # The final layers
 will have the base lr.
            ], lr=0.001, weight_decay=0.005)
```

Train and evaluate

In [5]:
```python
model_ft = train_model(model_ft, criterion, optimizer_ft, scheduler="",
                       num_epochs=30)
```

```
Epoch 0/29
----------
train Loss: 0.7791 Acc: 0.6431
val Loss: 0.8917 Acc: 0.5815

Epoch 1/29
----------
train Loss: 0.6267 Acc: 0.7277
val Loss: 0.8930 Acc: 0.6518

Epoch 2/29
----------
train Loss: 0.5461 Acc: 0.7671
val Loss: 1.0044 Acc: 0.6261

Epoch 3/29
----------
train Loss: 0.4804 Acc: 0.8023
val Loss: 1.0667 Acc: 0.6346

Epoch 4/29
----------
train Loss: 0.4165 Acc: 0.8302
val Loss: 1.0281 Acc: 0.6449

Epoch 5/29
----------
train Loss: 0.3717 Acc: 0.8518
val Loss: 1.0878 Acc: 0.6226

Epoch 6/29
----------
train Loss: 0.3289 Acc: 0.8730
val Loss: 1.1686 Acc: 0.6295

Epoch 7/29
----------
train Loss: 0.3002 Acc: 0.8851
val Loss: 1.1168 Acc: 0.6346

Epoch 8/29
----------
train Loss: 0.2690 Acc: 0.8980
val Loss: 1.2810 Acc: 0.6295

Epoch 9/29
----------
train Loss: 0.2514 Acc: 0.9053
val Loss: 1.2825 Acc: 0.6089

Epoch 10/29
----------
train Loss: 0.2407 Acc: 0.9112
val Loss: 1.2380 Acc: 0.6278

Epoch 11/29
----------
train Loss: 0.2265 Acc: 0.9174
val Loss: 1.5244 Acc: 0.6261

Epoch 12/29
----------
train Loss: 0.2056 Acc: 0.9256
val Loss: 1.3618 Acc: 0.6432

Epoch 13/29
----------
train Loss: 0.1992 Acc: 0.9289
val Loss: 1.3390 Acc: 0.6158

Epoch 14/29
----------
train Loss: 0.1900 Acc: 0.9327
val Loss: 1.3633 Acc: 0.6244

Epoch 15/29
----------
train Loss: 0.1842 Acc: 0.9354
val Loss: 1.3621 Acc: 0.6381

Epoch 16/29
----------
train Loss: 0.1770 Acc: 0.9379
val Loss: 1.3304 Acc: 0.6329

Epoch 17/29
----------
train Loss: 0.1739 Acc: 0.9398
val Loss: 1.4402 Acc: 0.6329

Epoch 18/29
----------
train Loss: 0.1671 Acc: 0.9428
val Loss: 1.1744 Acc: 0.6312

Epoch 19/29
----------
train Loss: 0.1579 Acc: 0.9462
val Loss: 1.3094 Acc: 0.6295

Epoch 20/29
----------
train Loss: 0.1496 Acc: 0.9495
val Loss: 1.4150 Acc: 0.6123

Epoch 21/29
----------
train Loss: 0.1530 Acc: 0.9481
val Loss: 1.3933 Acc: 0.5918

Epoch 22/29
----------
train Loss: 0.1454 Acc: 0.9525
val Loss: 1.4213 Acc: 0.6398

Epoch 23/29
----------
train Loss: 0.1398 Acc: 0.9542
val Loss: 1.4791 Acc: 0.6329

Epoch 24/29
----------
train Loss: 0.1391 Acc: 0.9538
val Loss: 1.3622 Acc: 0.6175

Epoch 25/29
----------
train Loss: 0.1379 Acc: 0.9542
val Loss: 1.3928 Acc: 0.6346

Epoch 26/29
----------
train Loss: 0.1350 Acc: 0.9558
val Loss: 1.4319 Acc: 0.6226

Epoch 27/29
----------
train Loss: 0.1388 Acc: 0.9538
val Loss: 1.4723 Acc: 0.6244

Epoch 28/29
----------
train Loss: 0.1182 Acc: 0.9629
val Loss: 1.5996 Acc: 0.5952

Epoch 29/29
----------
train Loss: 0.1266 Acc: 0.9587
val Loss: 1.3637 Acc: 0.6192
```






```
Training complete in 111m 30s
Best val Acc: 0.651801
```

In [6]:
```python
# Display the time and date when this is run (to use for saving the model).
dt = time.strftime("%Y%m%d-%H%M%S")
dt
```

Out[6]:
```
'20190412-173702'
```

In [7]:
```python
# Save best model to disk for later (inference/testing)!
torch.save(model_ft.state_dict(), 'D:\\Models\\' + 'model_' + dt + '.pth')
```

In [8]:
```python
# Play sound when code finishes.

import winsound
duration = 1500  # milliseconds
```