In [ ]:

```python
import torch
import torchvision
import numpy as np
import matplotlib.pyplot as plt
import torch.nn as nn
import torch.nn.functional as F
from torchvision.datasets import FashionMNIST
from torchvision.transforms import ToTensor
from torchvision.utils import make_grid
from torch.utils.data.dataloader import DataLoader
from torch.utils.data import random_split
import os
from torchvision.datasets import ImageFolder
import torchvision.transforms as tt
from tqdm import tqdm
from torch.utils.data.dataloader import DataLoader
import torch.nn as nn
import torch.nn.functional as F
import matplotlib.pyplot as plt
%matplotlib inline
```

In [ ]:

```python
! pip install -q kaggle
from google.colab import files
files.upload()
! mkdir ~/.kaggle
! cp kaggle.json ~/.kaggle/
! chmod 600 ~/.kaggle/kaggle.json
```

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```
Saving kaggle.json to kaggle.json
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In [ ]:

```python
! kaggle datasets download grassknoted/asl-alphabet
! unzip asl-alphabet.zip
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```

In [ ]:

```
def show_example(img, label):
    print('Label: ', dataset.classes[label], "("+str(label)+")")
    plt.imshow((img.permute(1, 2, 0)))



classes = os.listdir("asl_alphabet_train/asl_alphabet_train")
len(classes)
image_size = 32*32
transform = tt.Compose(
    [
        tt.Resize(32),
        tt.ToTensor(),
        tt.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))
    ]
)
dataset = ImageFolder("asl_alphabet_train/asl_alphabet_train", transform)
val_size = 7000
test_size = 14000
train_size = len(dataset) - val_size - test_size
train_ds, val_ds, test_ds = random_split(dataset, [train_size, val_size, test_size])

batch_size = 32
train_dl = DataLoader(train_ds, batch_size, shuffle=True)
val_dl = DataLoader(val_ds, batch_size*2)
test_dl = DataLoader(test_ds, batch_size*2)
```

In [ ]:

```
def get_device():
    if torch.cuda.is_available():
        return torch.device('cuda')
    else:
        return torch.device('cpu')

def to_device(data, device):
    if isinstance(data, (list,tuple)):
        return [to_device(x, device) for x in data]
    return data.to(device, non_blocking=True)

device = get_device()
```

In [ ]:

```
batch_size=64

train_dl = DataLoader(train_ds, batch_size, shuffle=True, num_workers=4, pin_memory=True)
val_dl = DataLoader(val_ds, batch_size*2, num_workers=4, pin_memory=True)
test_dl = DataLoader(test_ds, batch_size*2, num_workers=4, pin_memory=True)
```

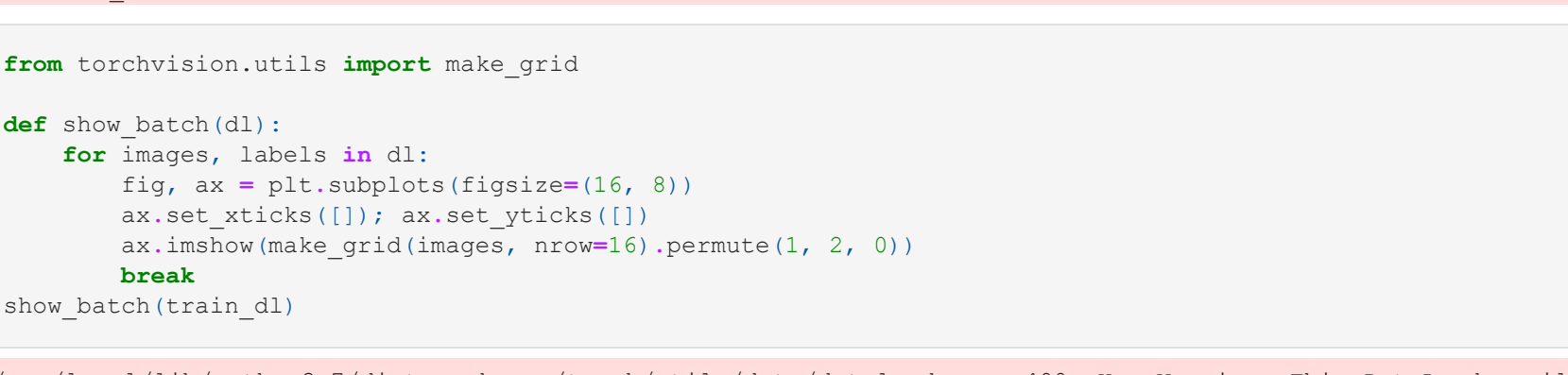
```
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490: UserWarning: This DataLoader will cr
eate 4 worker processes in total. Our suggested max number of worker in current system is 2, which is smaller t
han what this DataLoader is going to create. Please be aware that excessive worker creation might get DataLoade
r running slow or even freeze, lower the worker number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
```

In [ ]:

```
from torchvision.utils import make_grid

def show_batch(dl):
    for images, labels in dl:
        fig, ax = plt.subplots(figsize=(16, 8))
        ax.set_xticks([]); ax.set_yticks([])
        ax.imshow(make_grid(images, nrow=16).permute(1, 2, 0))
        break
show_batch(train_dl)
```

```
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490: UserWarning: This DataLoader will cr
eate 4 worker processes in total. Our suggested max number of worker in current system is 2, which is smaller t
han what this DataLoader is going to create. Please be aware that excessive worker creation might get DataLoade
r running slow or even freeze, lower the worker number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```



In [ ]:

```
def accuracy(outputs, labels):
    _, preds = torch.max(outputs, dim=1)
    return torch.tensor(torch.sum(preds == labels).item() / len(preds))

class ASLDeepNeuralNetwork(nn.Module):
    def __init__(self, input_size, output_size):
        super().__init__()
        self.network = nn.Sequential(
            nn.Linear(input_size , 128),
            nn.ReLU(),
            nn.Linear(128, output_size)
        )

    def forward(self, xb):
        return self.network(xb.view(xb.size(0), -1))

    def training_step(self, batch):
        images, labels = batch
        out = self(images)
        loss = F.cross_entropy(out, labels)
        return loss

    def validation_step(self, batch):
        images, labels = batch
        out = self(images)
        loss = F.cross_entropy(out, labels)
        acc = accuracy(out, labels)
        return {'val_loss': loss.detach(), 'val_acc': acc}

    def validation_epoch_end(self, outputs):
        batch_losses = [x['val_loss'] for x in outputs]
        epoch_loss = torch.stack(batch_losses).mean()   # Combine losses
        batch_accs = [x['val_acc'] for x in outputs]
        epoch_acc = torch.stack(batch_accs).mean()      # Combine accuracies
        return {'val_loss': epoch_loss.item(), 'val_acc': epoch_acc.item()}

    def epoch_end(self, epoch, result):
        print("Epoch [{}], train_loss: {:.4f}, val_loss: {:.4f}, val_acc: {:.4f}".format(
            epoch, result['train_loss'], result['val_loss'], result['val_acc']))

@torch.no_grad()
def evaluate(model, val_dl):
    model.eval()
    outputs = [model.validation_step(batch) for batch in val_dl]
    return model.validation_epoch_end(outputs)

def fit(epochs, lr, model, train_dl, val_dl, opt_func=torch.optim.SGD):
    history = []
    optimizer = opt_func(model.parameters(), lr)
    for epoch in range(epochs):
        # Training Phase
        model.train()
        train_losses = []
        for batch in tqdm(train_dl):
            loss = model.training_step(batch)
            train_losses.append(loss)
            loss.backward()
            optimizer.step()
            optimizer.zero_grad()
        # Validation phase
        result = evaluate(model, val_dl)
        result['train_loss'] = torch.stack(train_losses).mean().item()
        model.epoch_end(epoch, result)
        history.append(result)
    return history

input_size = 3*32*32
output_size = 29
DNN = ASLDeepNeuralNetwork(input_size, output_size)
train_dl = DeviceDataLoader(train_dl, device)
val_dl = DeviceDataLoader(val_dl, device)
test_dl = DeviceDataLoader(test_dl, device)
to_device(DNN, device);
num_epochs = 10
opt_func = torch.optim.Adam
lr = 0.0001
history = fit(num_epochs, lr, DNN, train_dl, val_dl, opt_func)
torch.save(DNN.state_dict(), 'DNN.pth')
```

```
  0%|          | 0/1032 [00:00<?, ?it/s]/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:4
90: UserWarning: This DataLoader will create 4 worker processes in total. Our suggested max number of worker in
current system is 2, which is smaller than what this DataLoader is going to create. Please be aware that excess
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l slowness/freeze if necessary.
  cpuset_checked))
100%|██████████| 1032/1032 [01:09<00:00, 14.87it/s]
Epoch [0], train_loss: 2.4195, val_loss: 1.9598, val_acc: 0.4533
100%|██████████| 1032/1032 [01:12<00:00, 14.16it/s]
Epoch [1], train_loss: 1.7223, val_loss: 1.5327, val_acc: 0.5779
100%|██████████| 1032/1032 [01:09<00:00, 14.86it/s]
Epoch [2], train_loss: 1.3957, val_loss: 1.2867, val_acc: 0.6500
100%|██████████| 1032/1032 [01:14<00:00, 13.83it/s]
Epoch [3], train_loss: 1.1819, val_loss: 1.1184, val_acc: 0.6968
100%|██████████| 1032/1032 [01:12<00:00, 14.21it/s]
Epoch [4], train_loss: 1.0241, val_loss: 0.9757, val_acc: 0.7421
100%|██████████| 1032/1032 [01:08<00:00, 15.15it/s]
Epoch [5], train_loss: 0.9012, val_loss: 0.8714, val_acc: 0.7696
100%|██████████| 1032/1032 [01:08<00:00, 15.12it/s]
Epoch [6], train_loss: 0.8013, val_loss: 0.7872, val_acc: 0.7917
100%|██████████| 1032/1032 [01:11<00:00, 14.48it/s]
Epoch [7], train_loss: 0.7176, val_loss: 0.7108, val_acc: 0.8184
100%|██████████| 1032/1032 [01:09<00:00, 14.84it/s]
Epoch [8], train_loss: 0.6482, val_loss: 0.6515, val_acc: 0.8357
100%|██████████| 1032/1032 [01:07<00:00, 15.27it/s]
Epoch [9], train_loss: 0.5884, val_loss: 0.5949, val_acc: 0.8440
```

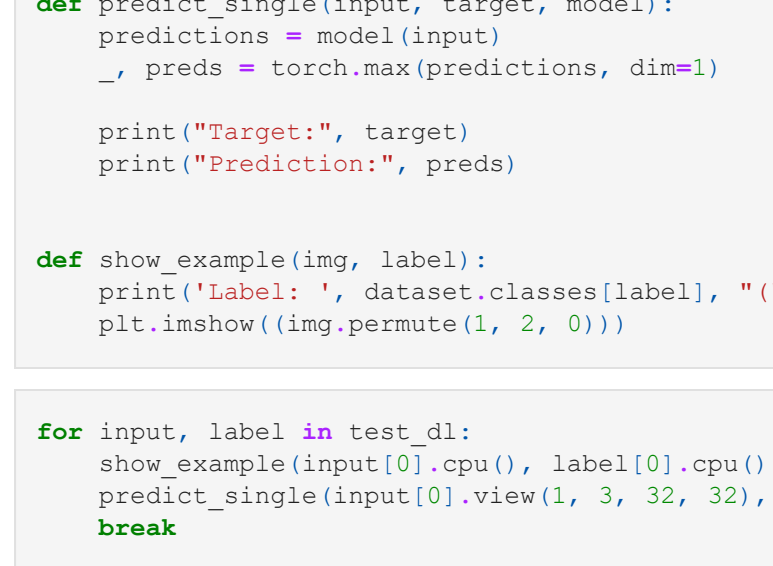
In [ ]:

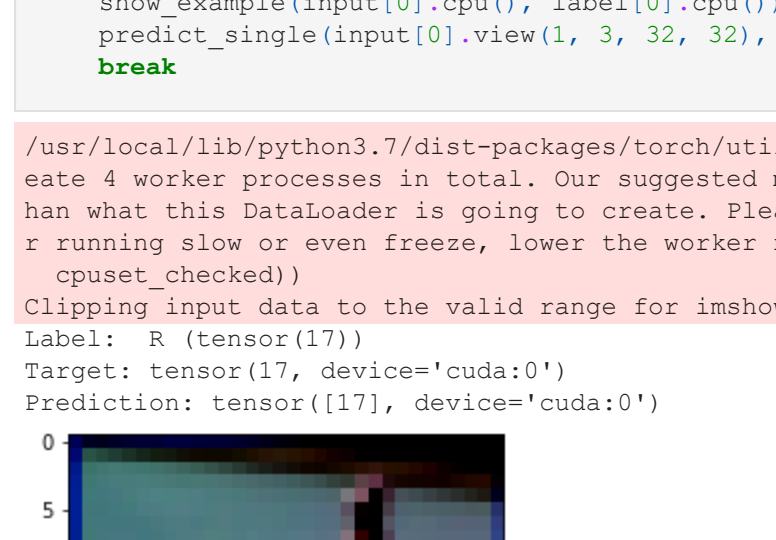
```
def plot_accuracies(history):
    accuracies = [x['val_acc'] for x in history]
    plt.plot(accuracies, '-x')
    plt.xlabel('epoch')
    plt.ylabel('accuracy')
    plt.title('Accuracy vs. No. of epochs');
    plt.show()

def plot_losses(history):
    train_losses = [x.get('train_loss') for x in history]
    val_losses = [x['val_loss'] for x in history]
    plt.plot(train_losses, '-bx')
    plt.plot(val_losses, '-rx')
    plt.xlabel('epoch')
    plt.ylabel('loss')
    plt.legend(['Training', 'Validation'])
    plt.title('Loss vs. No. of epochs');
    plt.show()

print(evaluate(DNN, test_dl))
plot_accuracies(history)
plot_losses(history)
```

```
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490: UserWarning: This DataLoader will cr
eate 4 worker processes in total. Our suggested max number of worker in current system is 2, which is smaller t
han what this DataLoader is going to create. Please be aware that excessive worker creation might get DataLoade
r running slow or even freeze, lower the worker number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
{'val_loss': 0.6020750999450684, 'val_acc': 0.8466619253158569}
```





In [ ]:

```
def predict_single(input, target, model):
    predictions = model(input)
    _, preds = torch.max(predictions, dim=1)

    print("Target:", target)
    print("Prediction:", preds)


def show_example(img, label):
    print('Label: ', dataset.classes[label], "("+str(label)+")")
    plt.imshow((img.permute(1, 2, 0)))
```

In [ ]:

```
for input, label in test_dl:
    show_example(input[0].cpu(), label[0].cpu())
    predict_single(input[0].view(1, 3, 32, 32), label[0], DNN)
    break
```

```
/usr/local/lib/python3.7/dist-packages/torch/utils/data/dataloader.py:490: UserWarning: This DataLoader will cr
eate 4 worker processes in total. Our suggested max number of worker in current system is 2, which is smaller t
han what this DataLoader is going to create. Please be aware that excessive worker creation might get DataLoade
r running slow or even freeze, lower the worker number to avoid potential slowness/freeze if necessary.
  cpuset_checked))
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
Label:  R (tensor(17))
Target: tensor(17, device='cuda:0')
Prediction: tensor([17], device='cuda:0')
```


In [ ]:

```
torch.save({'model_state_dict': DNN.state_dict()}, "model.pt")
```