Pytorch Basics

```
import numpy as np
import torch
import torchvision
import matplotlib.pyplot as plt
```

```
trainingdata = torchvision.datasets.FashionMNIST('./FashionMNIST/',train=True,download=True,transform=torchvision.transforms.ToTer
testdata = torchvision.datasets.FashionMNIST('./FashionMNIST/',train=False,download=True,transform=torchvision.transforms.ToTensor
```

```
Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/train-ima
Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/train-ima
100%                                      26421880/26421880 [00:01<00:00, 23672680.84it/s]
Extracting ./FashionMNIST/FashionMNIST/raw/train-images-idx3-ubyte.gz to ./Fashi

Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/train-labe
Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/train-labe
100%                                      29515/29515 [00:00<00:00, 259354.61it/s]
Extracting ./FashionMNIST/FashionMNIST/raw/train-labels-idx1-ubyte.gz to ./Fashi

Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/t10k-image
Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/t10k-image
100%                                      4422102/4422102 [00:00<00:00, 5142966.64it/s]
Extracting ./FashionMNIST/FashionMNIST/raw/t10k-images-idx3-ubyte.gz to ./Fashio

Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/t10k-label
Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/t10k-label
100%                                      5148/5148 [00:00<00:00, 51337.33it/s]
Extracting ./FashionMNIST/FashionMNIST/raw/t10k-labels-idx1-ubyte.gz to ./Fashio
```

```
trainDataLoader = torch.utils.data.DataLoader(trainingdata,batch_size=128,shuffle=True) #loads images in batches of 64
testDataLoader = torch.utils.data.DataLoader(testdata,batch_size=128,shuffle=False)
```

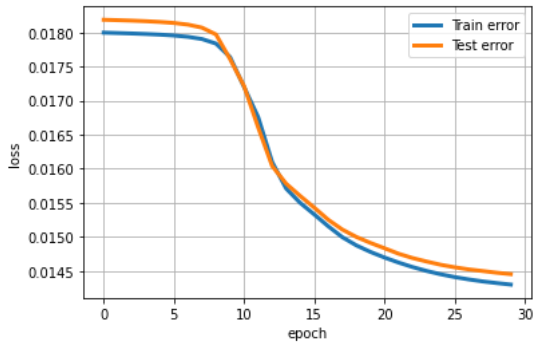
```
import torch.nn as nn
class LinearReg(torch.nn.Module):
  def __init__(self): # sets up architecture of the model with input and output node counts
    super(LinearReg, self).__init__()
    self.linear = torch.nn.Linear(28*28, 10) #(input dimension (pixels), output dimension (labels))
    self.model = nn.Sequential(
        nn.Linear(784, 256),
        nn.ReLU(),
        nn.Linear(256, 128),
        nn.ReLU(),
        nn.Linear(128, 64),
        nn.ReLU(),
        nn.Linear(64, 10),
        nn.Softmax()
    )



  def forward(self, x): #formats the input data so it can be read by the model
    x = x.view(-1, 28*28) # change so 784 vector long instead of 28x28 matrix
    return self.model(x) #gets outputs of labels

model = LinearReg() # Step 1: architecture
loss = torch.nn.CrossEntropyLoss() # Step 2: loss
optimizer = torch.optim.SGD(model.parameters(), lr=0.01) # Step 3: training method
```

```
train_loss_history = [] # used to track loss in the training dataset
test_loss_history = [] # used to track loss in the test dataset

# Training process
# training network on training data
for epoch in range(30):
  train_loss = 0.0
```

```
    test_loss = 0.0
    for i, data in enumerate(trainDataLoader): # loop through training data
      images, labels = data #splits data
      optimizer.zero_grad() #magic
      predicted_output = model(images) # run the model on the images and store its prediction
      fit = loss(predicted_output, labels) # calculates the loss function for model accuracy
      fit.backward() # computes the gradient of the loss tensor
      optimizer.step() #performs a round of optimization
      train_loss += fit.item() / len(trainingdata) #adds the loss to the total loss for that epoch
      #to compare because the lengths of training and test are not the same
  # Validation
  # How well are we doing on data we haven't seen yet?

    for i, data in enumerate(testDataLoader):
      with torch.no_grad():
        images, labels = data
        predicted_output = model(images)
        fit = loss(predicted_output, labels)
        test_loss += fit.item() / len(testdata)
    train_loss_history += [train_loss]
    test_loss_history += [test_loss]
    print(f'Epoch {epoch}, Train loss {train_loss}, Test loss {test_loss}')
```

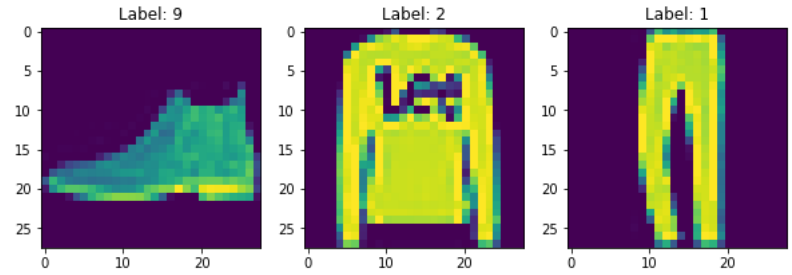
```
/usr/local/lib/python3.8/dist-packages/torch/nn/modules/container.py:204: UserWarning: Implicit dimension choice for softmax
  input = module(input)
Epoch 0, Train loss 0.01799738526344296, Test loss 0.01818626461029052
Epoch 1, Train loss 0.01799128493070603, Test loss 0.018180249619483946
Epoch 2, Train loss 0.017985045814514166, Test loss 0.018173562240600596
Epoch 3, Train loss 0.017977523215611763, Test loss 0.01816516559123993
Epoch 4, Train loss 0.017968041789531708, Test loss 0.018154363608360292
Epoch 5, Train loss 0.017955209414164227, Test loss 0.01813903112411499
Epoch 6, Train loss 0.017936010781923927, Test loss 0.01811502294540405
Epoch 7, Train loss 0.017903660190105457, Test loss 0.018070810818672185
Epoch 8, Train loss 0.017836454621950795, Test loss 0.017970486164093018
Epoch 9, Train loss 0.017639294906457277, Test loss 0.017609318351745604
Epoch 10, Train loss 0.017199900941054006, Test loss 0.017212201642990116
Epoch 11, Train loss 0.016759768195947, Test loss 0.01660888202190399
Epoch 12, Train loss 0.016099170676867173, Test loss 0.016040403187274937
Epoch 13, Train loss 0.01570859369834263, Test loss 0.015780556750297547
Epoch 14, Train loss 0.015498809407154715, Test loss 0.01560049492120742
Epoch 15, Train loss 0.015329496381680187, Test loss 0.01542953314781189
Epoch 16, Train loss 0.015155265891551972, Test loss 0.015251087749004362
Epoch 17, Train loss 0.014995739249388384, Test loss 0.015107599198818206
Epoch 18, Train loss 0.014875297480821626, Test loss 0.0149991788983345
Epoch 19, Train loss 0.01477984542250632, Test loss 0.014912271916866303
Epoch 20, Train loss 0.01469758782784144, Test loss 0.01483384813070298
Epoch 21, Train loss 0.014623915495475122, Test loss 0.014753595483303066
Epoch 22, Train loss 0.014557912987470622, Test loss 0.014689983212947844
Epoch 23, Train loss 0.014500498723983766, Test loss 0.014638720202445983
Epoch 24, Train loss 0.014451992599169402, Test loss 0.014591575860977167
Epoch 25, Train loss 0.0144106296022733, Test loss 0.014554183733463285
Epoch 26, Train loss 0.014376422291994092, Test loss 0.014523262071609495
Epoch 27, Train loss 0.01434670092264812, Test loss 0.014499241936206815
Epoch 28, Train loss 0.014322624192635223, Test loss 0.014474314689636234
Epoch 29, Train loss 0.014300333789984382, Test loss 0.014453886604309085
```

```
plt.plot(range(30),train_loss_history,'-',linewidth=3, label='Train error')
plt.plot(range(30),test_loss_history,'-',linewidth=3, label='Test error')
plt.xlabel('epoch')
plt.ylabel('loss')
plt.grid(True)
plt.legend()
plt.show()
```

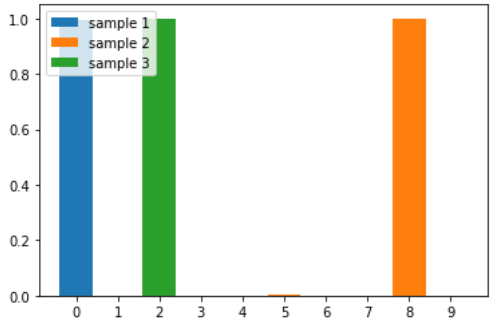


```
images, labels = next(iter(testDataLoader))
plt.figure(figsize=(10,10))

predicted_output = model(images)
print('Predicted:', torch.max(predicted_output, 1)[1].numpy()[0:3])

for index in np.arange(0,3):
    plt.subplot(1,3,index+1)
    plt.title(f'Label: {labels[index].item()}')
    plt.imshow(images[index].cpu().squeeze().numpy())
```

```
Predicted: [9 2 1]
```




```
guess = ["0", "1", "2", "3", "4", "5", "6", "7", "8", "9"]
predict1 = predicted_output.detach().numpy()[1]
predict2 = predicted_output.detach().numpy()[2]
predict3 = predicted_output.detach().numpy()[3]
plt.bar(guess, predict1, label = "sample 1")
plt.bar(guess, predict2, label = "sample 2")
plt.bar(guess, predict3, label = "sample 3")
plt.legend(loc = "upper left")
plt.show()
```



Based on this predicted probability, the model is very sure about sample 1 being 0, sample 2 being 8 and sample 3 being 2. Looking at the output below for the 1st, 2nd, and 3rd indices, we see that the model is correct.

```
images, labels = next(iter(trainDataLoader))
predicted_output = model(images)
print('Predicted:', torch.max(predicted_output, 1)[1])
fit = loss(predicted_output, labels)
print('True labels:', labels)
print(fit.item())
```

```
Predicted: tensor([7, 0, 8, 2, 7, 1, 1, 0, 1, 0, 2, 2, 2, 2, 2, 2, 2, 2, 7, 7, 5, 2, 5,
        0, 2, 9, 5, 0, 8, 7, 7, 8, 0, 9, 5, 9, 1, 0, 2, 1, 1, 1, 9, 0, 2, 1, 5,
        2, 2, 7, 7, 2, 0, 1, 8, 2, 2, 2, 0, 1, 8, 2, 8, 0, 1, 2, 8, 8, 9, 1, 0,
        2, 2, 9, 7, 0, 0, 2, 2, 8, 8, 1, 0, 5, 2, 1, 0, 5, 7, 5, 2, 2, 7, 1, 0,
        7, 7, 2, 7, 9, 0, 8, 5, 9, 2, 2, 5, 5, 0, 1, 1, 7, 8, 1, 7, 9, 1, 2, 9,
        2, 7, 2, 7, 2, 1, 2, 0])
True labels: tensor([7, 0, 8, 2, 7, 3, 1, 0, 0, 6, 2, 1, 4, 2, 6, 2, 6, 6, 6, 5, 9, 5, 2, 5,
        0, 4, 9, 5, 0, 8, 7, 7, 8, 0, 9, 5, 5, 1, 3, 6, 1, 1, 3, 9, 3, 6, 1, 5,
        4, 4, 9, 7, 6, 0, 1, 8, 6, 2, 6, 3, 1, 8, 4, 6, 0, 1, 6, 8, 8, 9, 3, 0,
        6, 8, 9, 7, 0, 0, 2, 4, 5, 8, 3, 0, 5, 4, 3, 0, 5, 7, 5, 6, 6, 7, 3, 0,
        7, 7, 2, 7, 9, 3, 8, 5, 9, 2, 6, 5, 5, 6, 1, 3, 5, 8, 1, 7, 9, 1, 2, 9,
        2, 7, 4, 7, 2, 1, 2, 6])
1.8236931562423706
```