In [1]:
```
import torch
import torch.nn as nn
import torch.nn.functional as F
import torchvision
import numpy as np
import pandas as pd
from matplotlib import pyplot as plt
```

In [2]:
```
# Detect if we have a GPU available
device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
if torch.cuda.is_available():
    print("Using the GPU!")
else:
    print("WARNING: Could not find GPU! Using CPU only")
```

```
Using the GPU!
```

In [3]:
```
x_train_nhts = np.load("data/x_train_nhts.npy")
x_test_nhts = np.load("data/x_test_nhts.npy")

x_train_images = np.load("data/x_train_images.npy")
x_test_images = np.load("data/x_test_images.npy")


y_train = np.load("data/y_train.npy")
y_test = np.load("data/y_test.npy")
print("The sample size of training set is: ", x_train_nhts.shape[0])
print("The sample size of testing set is: ", x_test_nhts.shape[0])
```

```
The sample size of training set is:  3556
The sample size of testing set is:  889
```

In [4]:
```
# bridge numpy to torch
x_train_nhts_torch = torch.as_tensor(x_train_nhts).float() # specify floa
x_train_images_torch = torch.as_tensor(x_train_images).float()
x_test_nhts_torch = torch.as_tensor(x_test_nhts).float()
x_test_images_torch = torch.as_tensor(x_test_images).float()
y_train_torch = torch.as_tensor(y_train[:,0])
y_test_torch = torch.as_tensor(y_test[:,0])
n_train = x_train_nhts.shape[0]
n_test = x_test_nhts.shape[0]
# inputs: x_train_nhts, x_train_images, x_test_nhts, x_test_images, y_tra
K = len(np.unique(y_train))
print(K)
x_dim = x_train_nhts.shape[1]
print("x_dim", x_dim)
#
pd.value_counts(y_train[:,0])/y_train.shape[0]
```

```
4
x_dim 7
```

Out[4]:
```
2    0.339145
1    0.323960
3    0.249438
0    0.087458
dtype: float64
```

In [5]:
```
class combinedNN(nn.Module):
    def __init__(self):
        super(combinedNN, self).__init__()
        # To-Do: need to have more channels for higher accuracy.
        self.conv1 = nn.Conv2d(in_channels=4, out_channels=5, kernel_size
        self.conv2 = nn.Conv2d(in_channels=5, out_channels=10, kernel_siz
        # Question: Why is this 48*48 correct?
        self.fcCNN1 = nn.Linear(in_features=10 * 48 * 48, out_features=10
        self.fcCNN2 = nn.Linear(in_features=100, out_features=100)
        #
        self.fcNN1 = nn.Linear(x_dim, 100)
        self.fcNN2 = nn.Linear(100, 100)
        self.fcNN3 = nn.Linear(100, 100)
        #
        self.fcNN = nn.Linear(200, K)
        self.softmax = nn.Softmax(dim=1)

    def forward(self, image, nhts):
        #image
        outCNN = F.relu(self.conv1(image))
        outCNN = F.max_pool2d(outCNN, 2)
        outCNN = F.relu(self.conv2(outCNN))
        outCNN = F.max_pool2d(outCNN, 2)
        outCNN = outCNN.reshape(outCNN.size(0), -1)
        outCNN = F.relu(self.fcCNN1(outCNN))
        outCNN = F.relu(self.fcCNN2(outCNN))
        #nhts
        nhts = self.fcNN1(nhts)
        nhts = nhts.relu()
        nhts = self.fcNN2(nhts)
        nhts = nhts.relu()
        nhts = self.fcNN3(nhts)
        #combined
        out = self.fcNN(torch.cat((nhts,outCNN),1)) #200*4
        out = self.softmax(out) # 200*4
        return out
```

In [6]:
```
# normalize the data
x_train_images_norm_torch = x_train_images_torch/255.0
x_test_images_norm_torch = x_test_images_torch/255.0
#
combined_net = combinedNN().float().to(device)
optim = torch.optim.Adam(combined_net.parameters(), lr=0.001)
criterion = nn.CrossEntropyLoss()
#
n_epoches = 150 # To-Do: need more epoches.
batch_size = 200
```

In [7]:
```
# training
```

In [7]:

```
# training
train_losses = []
test_losses = []
train_accuracies = []
test_accuracies = []
for n_epoch in range(n_epoches):
    # create permutation for batch training
    # To-Do: add permutation for SGD...But it is slow.
#     permutation = torch.randperm(x_train_images_norm_torch.size()[0])
    for i in range(0, x_train_images_norm_torch.size()[0], batch_size):
        print(n_epoch, i)
        # clear gradients first (for each iteration!)!
        optim.zero_grad()
        # forward pass
        batch_x_image, batch_y = x_train_images_norm_torch[i:i+batch_size

        batch_x_nhts = x_train_nhts_torch[i:i+batch_size].to(device)

        batch_y_pred_train = combined_net(batch_x_image.to(device), batch
        # loss
        loss = criterion(batch_y_pred_train.squeeze(), batch_y)
        # compute gradients
        loss.backward()
        # one step optim
        optim.step()

    # eval training accuracy
    with torch.no_grad():
        y_pred_train = combined_net(x_train_images_norm_torch.to(device),
        loss_train = criterion(y_pred_train.squeeze(), y_train_torch.to(d
        train_losses.append(loss_train)
        _, predict_train = torch.max(y_pred_train, axis = 1)
        accuracy_train = (predict_train == y_train_torch.to(device)).sum(
        train_accuracies.append(accuracy_train)
        # evaluate testing sets step-wise
        combined_net.eval()
        y_pred_test = combined_net(x_test_images_norm_torch.to(device),x_
        loss_test = criterion(y_pred_test.squeeze(), y_test_torch.to(devi
        test_losses.append(loss_test)
        _, predict_test = torch.max(y_pred_test.to(device), axis = 1)
        accuracy_test = (predict_test == y_test_torch.to(device)).sum().i
        test_accuracies.append(accuracy_test)
        # print info
        if n_epoch % 1 == 0:
            print('Epoch {}: train loss: {}; test loss: {}'.format(n_epoc
            print('Epoch {}: train accuracy: {}; test accuracy: {}'.forma

# notes:
# CPU training: about 30 mins, with SIMPLEST CNN architecture, 20 epoches
# training accuracy: 60%; testing accuracy: 60%.
```

```
0 0
0 200
0 400
0 600
0 800
0 1000
0 1200
0 1400
0 1600
0 1800
0 2000
0 2200
0 2400
0 2600
0 2800
0 3000
0 3200
0 3400
Epoch 0: train loss: 1.3084290027618408; test loss: 1.2675464153289795
Epoch 0: train accuracy: 0.4358830146231721; test accuracy: 0.43869516
310461193
1 0
1 200
1 400
1 600
1 800
1 1000
1 1200
1 1400
1 1600
1 1800
1 2000
1 2200
1 2400
1 2600
1 2800
1 3000
1 3200
1 3400
Epoch 1: train loss: 1.225966453552246; test loss: 1.253003478050232
Epoch 1: train accuracy: 0.483970753655793; test accuracy: 0.464566929
1338583
2 0
2 200
2 400
2 600
2 800
2 1000
2 1200
```

```
2 1400
2 1600
2 1800
2 2000
2 2200
2 2400
2 2600
2 2800
2 3000
2 3200
2 3400
Epoch 2: train loss: 1.1912152767181396; test loss: 1.2118353843688965
Epoch 2: train accuracy: 0.5438695163104612; test accuracy: 0.51631046
11923509
3 0
3 200
3 400
3 600
3 800
3 1000
3 1200
3 1400
3 1600
3 1800
3 2000
3 2200
3 2400
3 2600
3 2800
3 3000
3 3200
3 3400
Epoch 3: train loss: 1.1529314517974854; test loss: 1.1696364879608154
Epoch 3: train accuracy: 0.5956130483689539; test accuracy: 0.55905511
81102362
4 0
4 200
4 400
4 600
4 800
4 1000
4 1200
4 1400
4 1600
4 1800
4 2000
4 2200
4 2400
4 2600
4 2800
```

```
4 3000
4 3200
4 3400
Epoch 4: train loss: 1.1045429706573486; test loss: 1.1378178596496582
Epoch 4: train accuracy: 0.6448256467941508; test accuracy: 0.61979752
53093363
5 0
5 200
5 400
5 600
5 800
5 1000
5 1200
5 1400
5 1600
5 1800
5 2000
5 2200
5 2400
5 2600
5 2800
5 3000
5 3200
5 3400
Epoch 5: train loss: 1.074371576309204; test loss: 1.1008018255233765
Epoch 5: train accuracy: 0.6706974128233971; test accuracy: 0.63667041
61979753
6 0
6 200
6 400
6 600
6 800
6 1000
6 1200
6 1400
6 1600
6 1800
6 2000
6 2200
6 2400
6 2600
6 2800
6 3000
6 3200
6 3400
Epoch 6: train loss: 1.054840326309204; test loss: 1.0779086351394653
Epoch 6: train accuracy: 0.7050056242969629; test accuracy: 0.66141732
28346457
7 0
7 200
```

```
7 400
7 600
7 800
7 1000
7 1200
7 1400
7 1600
7 1800
7 2000
7 2200
7 2400
7 2600
7 2800
7 3000
7 3200
7 3400
Epoch 7: train loss: 1.0542646646499634; test loss: 1.0563104152679443
Epoch 7: train accuracy: 0.7024746906636671; test accuracy: 0.68503937
00787402
8 0
8 200
8 400
8 600
8 800
8 1000
8 1200
8 1400
8 1600
8 1800
8 2000
8 2200
8 2400
8 2600
8 2800
8 3000
8 3200
8 3400
Epoch 8: train loss: 1.0403450727462769; test loss: 1.0451164245605469
Epoch 8: train accuracy: 0.7241282339707537; test accuracy: 0.70078740
15748031
9 0
9 200
9 400
9 600
9 800
9 1000
9 1200
9 1400
9 1600
9 1800
```

```
9 2000
9 2200
9 2400
9 2600
9 2800
9 3000
9 3200
9 3400
Epoch 9: train loss: 1.0225794315338135; test loss: 1.0436135530471802
Epoch 9: train accuracy: 0.7232845894263217; test accuracy: 0.70641169
85376828
10 0
10 200
10 400
10 600
10 800
10 1000
10 1200
10 1400
10 1600
10 1800
10 2000
10 2200
10 2400
10 2600
10 2800
10 3000
10 3200
10 3400
Epoch 10: train loss: 1.0238765478134155; test loss: 1.028388381004333
5
Epoch 10: train accuracy: 0.7438132733408324; test accuracy: 0.7131608
548931384
11 0
11 200
11 400
11 600
11 800
11 1000
11 1200
11 1400
11 1600
11 1800
11 2000
11 2200
11 2400
11 2600
11 2800
11 3000
11 3200
```

```
11 3400
Epoch 11: train loss: 1.0114154815673828; test loss: 1.036331534385681
2
Epoch 11: train accuracy: 0.7336895388076491; test accuracy: 0.7210348
706411699
12 0
12 200
12 400
12 600
12 800
12 1000
12 1200
12 1400
12 1600
12 1800
12 2000
12 2200
12 2400
12 2600
12 2800
12 3000
12 3200
12 3400
Epoch 12: train loss: 1.0080486536026; test loss: 1.0232043266296387
Epoch 12: train accuracy: 0.7410011248593926; test accuracy: 0.7255343
082114736
13 0
13 200
13 400
13 600
13 800
13 1000
13 1200
13 1400
13 1600
13 1800
13 2000
13 2200
13 2400
13 2600
13 2800
13 3000
13 3200
13 3400
Epoch 13: train loss: 1.0062013864517212; test loss: 1.013847589492797
9
Epoch 13: train accuracy: 0.749437570303712; test accuracy: 0.73115860
51743532
14 0
14 200
```

```
14 400
14 600
14 800
14 1000
14 1200
14 1400
14 1600
14 1800
14 2000
14 2200
14 2400
14 2600
14 2800
14 3000
14 3200
14 3400
Epoch 14: train loss: 1.0156230926513672; test loss: 1.020191550254821
8
Epoch 14: train accuracy: 0.7530933633295838; test accuracy: 0.7289088
863892014
15 0
15 200
15 400
15 600
15 800
15 1000
15 1200
15 1400
15 1600
15 1800
15 2000
15 2200
15 2400
15 2600
15 2800
15 3000
15 3200
15 3400
Epoch 15: train loss: 0.9985557198524475; test loss: 1.010529041290283
2
Epoch 15: train accuracy: 0.7550618672665916; test accuracy: 0.7311586
051743532
16 0
16 200
16 400
16 600
16 800
16 1000
16 1200
16 1400
```

```
16 1600
16 1800
16 2000
16 2200
16 2400
16 2600
16 2800
16 3000
16 3200
16 3400
Epoch 16: train loss: 0.9984285235404968; test loss: 1.005347013473510
7
Epoch 16: train accuracy: 0.7649043869516311; test accuracy: 0.7412823
397075365
17 0
17 200
17 400
17 600
17 800
17 1000
17 1200
17 1400
17 1600
17 1800
17 2000
17 2200
17 2400
17 2600
17 2800
17 3000
17 3200
17 3400
Epoch 17: train loss: 0.9934443235397339; test loss: 1.000383257865905
8
Epoch 17: train accuracy: 0.7705286839145107; test accuracy: 0.7412823
397075365
18 0
18 200
18 400
18 600
18 800
18 1000
18 1200
18 1400
18 1600
18 1800
18 2000
18 2200
18 2400
18 2600
```

```
18 2800
18 3000
18 3200
18 3400
Epoch 18: train loss: 0.9866841435432434; test loss: 0.996870219707489
Epoch 18: train accuracy: 0.764341957255343; test accuracy: 0.74353205
84926884
19 0
19 200
19 400
19 600
19 800
19 1000
19 1200
19 1400
19 1600
19 1800
19 2000
19 2200
19 2400
19 2600
19 2800
19 3000
19 3200
19 3400
Epoch 19: train loss: 0.9852752685546875; test loss: 0.993730425834655
8
Epoch 19: train accuracy: 0.7764341957255343; test accuracy: 0.7547806
524184477
20 0
20 200
20 400
20 600
20 800
20 1000
20 1200
20 1400
20 1600
20 1800
20 2000
20 2200
20 2400
20 2600
20 2800
20 3000
20 3200
20 3400
Epoch 20: train loss: 0.9833945035934448; test loss: 0.989861071109771
7
Epoch 20: train accuracy: 0.78177727784027; test accuracy: 0.757030371
```

```
2035995
21 0
21 200
21 400
21 600
21 800
21 1000
21 1200
21 1400
21 1600
21 1800
21 2000
21 2200
21 2400
21 2600
21 2800
21 3000
21 3200
21 3400
Epoch 21: train loss: 0.9800364971160889; test loss: 0.987986147403717
Epoch 21: train accuracy: 0.78037120359955; test accuracy: 0.758155230
5961755
22 0
22 200
22 400
22 600
22 800
22 1000
22 1200
22 1400
22 1600
22 1800
22 2000
22 2200
22 2400
22 2600
22 2800
22 3000
22 3200
22 3400
Epoch 22: train loss: 0.9817704558372498; test loss: 0.986820459365844
7
Epoch 22: train accuracy: 0.7882452193475815; test accuracy: 0.7626546
681664792
23 0
23 200
23 400
23 600
23 800
23 1000
```

```
23 1200
23 1400
23 1600
23 1800
23 2000
23 2200
23 2400
23 2600
23 2800
23 3000
23 3200
23 3400
Epoch 23: train loss: 0.9783046245574951; test loss: 0.988213300704956
Epoch 23: train accuracy: 0.7845894263217098; test accuracy: 0.7570303
712035995
24 0
24 200
24 400
24 600
24 800
24 1000
24 1200
24 1400
24 1600
24 1800
24 2000
24 2200
24 2400
24 2600
24 2800
24 3000
24 3200
24 3400
Epoch 24: train loss: 0.9734959602355957; test loss: 0.981189787387847
9
Epoch 24: train accuracy: 0.7919010123734533; test accuracy: 0.7671541
057367829
25 0
25 200
25 400
25 600
25 800
25 1000
25 1200
25 1400
25 1600
25 1800
25 2000
25 2200
25 2400
```

```
25 2600
25 2800
25 3000
25 3200
25 3400
Epoch 25: train loss: 0.97503262758255; test loss: 0.9809976816177368
Epoch 25: train accuracy: 0.7935883014623172; test accuracy: 0.7660292
46344207
26 0
26 200
26 400
26 600
26 800
26 1000
26 1200
26 1400
26 1600
26 1800
26 2000
26 2200
26 2400
26 2600
26 2800
26 3000
26 3200
26 3400
Epoch 26: train loss: 0.9693894982337952; test loss: 0.977654337882995
6
Epoch 26: train accuracy: 0.7980877390326209; test accuracy: 0.7705286
839145107
27 0
27 200
27 400
27 600
27 800
27 1000
27 1200
27 1400
27 1600
27 1800
27 2000
27 2200
27 2400
27 2600
27 2800
27 3000
27 3200
27 3400
Epoch 27: train loss: 0.9710806012153625; test loss: 0.976570785045623
8
```

```
Epoch 27: train accuracy: 0.7986501687289089; test accuracy: 0.7694038
245219348
28 0
28 200
28 400
28 600
28 800
28 1000
28 1200
28 1400
28 1600
28 1800
28 2000
28 2200
28 2400
28 2600
28 2800
28 3000
28 3200
28 3400
Epoch 28: train loss: 0.9671714901924133; test loss: 0.974806129932403
6
Epoch 28: train accuracy: 0.7992125984251969; test accuracy: 0.7716535
433070866
29 0
29 200
29 400
29 600
29 800

29 1000
29 1200
29 1400
29 1600
29 1800
29 2000
29 2200
29 2400
29 2600
29 2800
29 3000
29 3200
29 3400
Epoch 29: train loss: 0.9716664552688599; test loss: 0.973348736763000
5
Epoch 29: train accuracy: 0.797806524184477; test accuracy: 0.77165354
33070866
30 0
30 200
30 400
```

```
30 600
30 800
30 1000
30 1200
30 1400
30 1600
30 1800
30 2000
30 2200
30 2400
30 2600
30 2800
30 3000
30 3200
30 3400
Epoch 30: train loss: 0.969884991645813; test loss: 0.9737409353256226
Epoch 30: train accuracy: 0.8000562429696289; test accuracy: 0.7727784
026996626
31 0
31 200
31 400
31 600
31 800
31 1000
31 1200
31 1400
31 1600
31 1800
31 2000
31 2200
31 2400
31 2600
31 2800
31 3000
31 3200
31 3400
Epoch 31: train loss: 0.9597621560096741; test loss: 0.966518402099609
4
Epoch 31: train accuracy: 0.8008998875140607; test accuracy: 0.7750281
214848144
32 0
32 200
32 400
32 600
32 800
32 1000
32 1200
32 1400
32 1600
32 1800
```

```
32 2000
32 2200
32 2400
32 2600
32 2800
32 3000
32 3200
32 3400
Epoch 32: train loss: 0.9673858880996704; test loss: 0.968137979507446
3
Epoch 32: train accuracy: 0.8025871766029247; test accuracy: 0.7761529
808773904
33 0
33 200
33 400
33 600
33 800
33 1000
33 1200
33 1400
33 1600
33 1800
33 2000
33 2200
33 2400
33 2600
33 2800
33 3000
33 3200
33 3400
Epoch 33: train loss: 0.959758460521698; test loss: 0.9667963981628418
Epoch 33: train accuracy: 0.8003374578177728; test accuracy: 0.7761529
808773904
34 0
34 200
34 400
34 600
34 800
34 1000
34 1200
34 1400
34 1600
34 1800
34 2000
34 2200
34 2400
34 2600
34 2800
34 3000
34 3200
```

```
34 3400
Epoch 34: train loss: 0.9642919898033142; test loss: 0.967126548290252
7
Epoch 34: train accuracy: 0.8017435320584927; test accuracy: 0.7750281
214848144
35 0
35 200
35 400
35 600
35 800
35 1000
35 1200
35 1400
35 1600
35 1800
35 2000
35 2200
35 2400
35 2600
35 2800
35 3000
35 3200
35 3400
Epoch 35: train loss: 0.9615095853805542; test loss: 0.964852035045623
8
Epoch 35: train accuracy: 0.8039932508436446; test accuracy: 0.7795275
590551181
36 0
36 200
36 400
36 600
36 800
36 1000
36 1200
36 1400
36 1600
36 1800
36 2000
36 2200
36 2400
36 2600
36 2800
36 3000
36 3200
36 3400
Epoch 36: train loss: 0.9610910415649414; test loss: 0.963051915168762
2
Epoch 36: train accuracy: 0.8025871766029247; test accuracy: 0.7784026
996625422
37 0
```

```
37 200
37 400
37 600
37 800
37 1000
37 1200
37 1400
37 1600
37 1800
37 2000
37 2200
37 2400
37 2600
37 2800
37 3000
37 3200
37 3400
Epoch 37: train loss: 0.957322359085083; test loss: 0.9659034609794617
Epoch 37: train accuracy: 0.8017435320584927; test accuracy: 0.7761529
808773904
38 0
38 200
38 400
38 600
38 800
38 1000
38 1200
38 1400
38 1600
38 1800
38 2000
38 2200
38 2400
38 2600
38 2800
38 3000
38 3200
38 3400
Epoch 38: train loss: 0.9622710943222046; test loss: 0.963790059089660
6
Epoch 38: train accuracy: 0.8028683914510686; test accuracy: 0.7784026
996625422
39 0
39 200
39 400
39 600
39 800
39 1000
39 1200
39 1400
```

```
39 1600
39 1800
39 2000
39 2200
39 2400
39 2600
39 2800
39 3000
39 3200
39 3400
Epoch 39: train loss: 0.9555616974830627; test loss: 0.964418411254882
8
Epoch 39: train accuracy: 0.8051181102362205; test accuracy: 0.7817772
7784027
40 0
40 200
40 400
40 600
40 800
40 1000
40 1200
40 1400
40 1600
40 1800
40 2000
40 2200
40 2400
40 2600
40 2800
40 3000
40 3200
40 3400
Epoch 40: train loss: 0.9602763652801514; test loss: 0.961373865604400
6
Epoch 40: train accuracy: 0.8037120359955006; test accuracy: 0.7806524
184476941
41 0
41 200
41 400
41 600
41 800
41 1000
41 1200
41 1400
41 1600
41 1800
41 2000
41 2200
41 2400
41 2600
```

```
41 2800
41 3000
41 3200
41 3400
Epoch 41: train loss: 0.9560214281082153; test loss: 0.964213311672210
7
Epoch 41: train accuracy: 0.8028683914510686; test accuracy: 0.7784026
996625422
42 0
42 200
42 400
42 600
42 800
42 1000
42 1200
42 1400
42 1600
42 1800
42 2000
42 2200
42 2400
42 2600
42 2800
42 3000
42 3200
42 3400
Epoch 42: train loss: 0.9605075120925903; test loss: 0.962281346321106
Epoch 42: train accuracy: 0.8023059617547806; test accuracy: 0.7784026
996625422
43 0
43 200
43 400
43 600
43 800
43 1000
43 1200
43 1400
43 1600
43 1800
43 2000
43 2200
43 2400
43 2600
43 2800
43 3000
43 3200
43 3400
Epoch 43: train loss: 0.9555473327636719; test loss: 0.961468219757080
1
Epoch 43: train accuracy: 0.8068053993250843; test accuracy: 0.7817772
```

```
7784027
44 0
44 200
44 400
44 600
44 800
44 1000
44 1200
44 1400
44 1600
44 1800
44 2000
44 2200
44 2400
44 2600
44 2800
44 3000
44 3200
44 3400
Epoch 44: train loss: 0.9589439630508423; test loss: 0.958815455436706
5
Epoch 44: train accuracy: 0.8068053993250843; test accuracy: 0.7851518
560179978
45 0
45 200
45 400
45 600
45 800
45 1000
45 1200
45 1400
45 1600
45 1800
45 2000
45 2200
45 2400
45 2600
45 2800
45 3000
45 3200
45 3400
Epoch 45: train loss: 0.9505254030227661; test loss: 0.956216454505920
4
Epoch 45: train accuracy: 0.8110236220472441; test accuracy: 0.7885264
341957255
46 0
46 200
46 400
46 600
46 800
```

```
46 1000
46 1200
46 1400
46 1600
46 1800
46 2000
46 2200
46 2400
46 2600
46 2800
46 3000
46 3200
46 3400
Epoch 46: train loss: 0.95172518491745; test loss: 0.943107545375824
Epoch 46: train accuracy: 0.811586051743532; test accuracy: 0.80089988
75140607
47 0
47 200
47 400
47 600
47 800
47 1000
47 1200
47 1400
47 1600
47 1800
47 2000
47 2200
47 2400
47 2600
47 2800
47 3000
47 3200
47 3400
Epoch 47: train loss: 0.9381769895553589; test loss: 0.9421346783638
Epoch 47: train accuracy: 0.8143982002249719; test accuracy: 0.8020247
469066367
48 0
48 200
48 400
48 600
48 800
48 1000
48 1200
48 1400
48 1600
48 1800
48 2000
48 2200
48 2400
```

```
48 2600
48 2800
48 3000
48 3200
48 3400
Epoch 48: train loss: 0.9356233477592468; test loss: 0.939904332160949
7
Epoch 48: train accuracy: 0.8174915635545557; test accuracy: 0.8065241
844769404
49 0
49 200
49 400
49 600
49 800
49 1000
49 1200
49 1400
49 1600
49 1800
49 2000
49 2200
49 2400
49 2600
49 2800
49 3000
49 3200
49 3400
Epoch 49: train loss: 0.9443773031234741; test loss: 0.942387878894805
9
Epoch 49: train accuracy: 0.812429696287964; test accuracy: 0.79977502
81214848
50 0
50 200
50 400
50 600
50 800
50 1000
50 1200
50 1400
50 1600
50 1800
50 2000
50 2200
50 2400
50 2600
50 2800
50 3000
50 3200
50 3400
Epoch 50: train loss: 0.9434457421302795; test loss: 0.941518008708953
```

```
9
Epoch 50: train accuracy: 0.8191788526434196; test accuracy: 0.8053993
250843644
51 0
51 200
51 400
51 600
51 800
51 1000
51 1200
51 1400
51 1600
51 1800
51 2000
51 2200
51 2400
51 2600
51 2800
51 3000
51 3200
51 3400
Epoch 51: train loss: 0.9409988522529602; test loss: 0.940233826637268
1
Epoch 51: train accuracy: 0.8149606299212598; test accuracy: 0.8020247
469066367
52 0
52 200
52 400
52 600
52 800
52 1000
52 1200
52 1400
52 1600
52 1800
52 2000
52 2200
52 2400
52 2600
52 2800
52 3000
52 3200
52 3400
Epoch 52: train loss: 0.9430555701255798; test loss: 0.940390467643737
8
Epoch 52: train accuracy: 0.8169291338582677; test accuracy: 0.8042744
656917885
53 0
53 200
53 400
```

```
53 600
53 800
53 1000
53 1200
53 1400
53 1600
53 1800
53 2000
53 2200
53 2400
53 2600
53 2800
53 3000
53 3200
53 3400
Epoch 53: train loss: 0.9299560785293579; test loss: 0.941690742969512
9
Epoch 53: train accuracy: 0.8158042744656918; test accuracy: 0.8020247
469066367
54 0
54 200
54 400
54 600
54 800
54 1000
54 1200
54 1400
54 1600
54 1800
54 2000
54 2200
54 2400
54 2600
54 2800
54 3000
54 3200
54 3400
Epoch 54: train loss: 0.9223721027374268; test loss: 0.938429117202758
8
Epoch 54: train accuracy: 0.8200224971878515; test accuracy: 0.8042744
656917885
55 0
55 200
55 400
55 600
55 800
55 1000
55 1200
55 1400
55 1600
```

```
55 1800
55 2000
55 2200
55 2400
55 2600
55 2800
55 3000
55 3200
55 3400
Epoch 55: train loss: 0.9196130633354187; test loss: 0.937568187713623
Epoch 55: train accuracy: 0.8214285714285714; test accuracy: 0.8053993
250843644
56 0
56 200
56 400
56 600
56 800
56 1000
56 1200
56 1400
56 1600
56 1800
56 2000
56 2200
56 2400
56 2600
56 2800
56 3000
56 3200
56 3400
Epoch 56: train loss: 0.9200430512428284; test loss: 0.941330194473266
6
Epoch 56: train accuracy: 0.8197412823397076; test accuracy: 0.8008998
875140607
57 0
57 200
57 400
57 600
57 800
57 1000
57 1200
57 1400
57 1600
57 1800
57 2000
57 2200
57 2400
57 2600
57 2800
57 3000
```

```
57 3200
57 3400
Epoch 57: train loss: 0.922438383102417; test loss: 0.9375696182250977
Epoch 57: train accuracy: 0.8236782902137233; test accuracy: 0.8087739
032620922
58 0
58 200
58 400
58 600
58 800
58 1000
58 1200
58 1400
58 1600
58 1800
58 2000
58 2200
58 2400
58 2600
58 2800
58 3000
58 3200
58 3400
Epoch 58: train loss: 0.9234593510627747; test loss: 0.936996817588806
2
Epoch 58: train accuracy: 0.8219910011248593; test accuracy: 0.8042744
656917885
59 0
59 200
59 400
59 600
59 800
59 1000
59 1200
59 1400
59 1600
59 1800
59 2000
59 2200
59 2400
59 2600
59 2800
59 3000
59 3200
59 3400
Epoch 59: train loss: 0.918164849281311; test loss: 0.9362740516662598
Epoch 59: train accuracy: 0.8264904386951631; test accuracy: 0.8098987
626546682
60 0
```

```
60 200
60 400
60 600
60 800
60 1000
60 1200
60 1400
60 1600
60 1800
60 2000
60 2200
60 2400
60 2600
60 2800
60 3000
60 3200
60 3400
Epoch 60: train loss: 0.9138844013214111; test loss: 0.935532987117767
3
Epoch 60: train accuracy: 0.8205849268841395; test accuracy: 0.8053993
250843644
61 0
61 200
61 400
61 600
61 800
61 1000
61 1200
61 1400
61 1600
61 1800
61 2000
61 2200
61 2400
61 2600
61 2800
61 3000
61 3200
61 3400
Epoch 61: train loss: 0.9169493317604065; test loss: 0.934138178825378
4
Epoch 61: train accuracy: 0.8248031496062992; test accuracy: 0.8098987
626546682
62 0
62 200
62 400
62 600
62 800
62 1000
62 1200
```

```
62 1400
62 1600
62 1800
62 2000
62 2200
62 2400
62 2600
62 2800
62 3000
62 3200
62 3400
Epoch 62: train loss: 0.9196025133132935; test loss: 0.936783850193023
7
Epoch 62: train accuracy: 0.8231158605174353; test accuracy: 0.8065241
844769404
63 0
63 200
63 400
63 600
63 800
63 1000
63 1200
63 1400
63 1600
63 1800
63 2000
63 2200
63 2400
63 2600
63 2800
63 3000
63 3200
63 3400
Epoch 63: train loss: 0.9148339629173279; test loss: 0.937411904335022
Epoch 63: train accuracy: 0.8231158605174353; test accuracy: 0.8042744
656917885
64 0
64 200
64 400
64 600
64 800
64 1000
64 1200
64 1400
64 1600
64 1800
64 2000
64 2200
64 2400
64 2600
```

```
64 2800
64 3000
64 3200
64 3400
Epoch 64: train loss: 0.9107182621955872; test loss: 0.936184763908386
2
Epoch 64: train accuracy: 0.8245219347581553; test accuracy: 0.8042744
656917885
65 0
65 200
65 400
65 600
65 800
65 1000
65 1200
65 1400
65 1600
65 1800
65 2000
65 2200
65 2400
65 2600
65 2800
65 3000
65 3200
65 3400
Epoch 65: train loss: 0.9105045795440674; test loss: 0.934847891330719
Epoch 65: train accuracy: 0.827334083239595; test accuracy: 0.80764904
38695163
66 0
66 200
66 400
66 600
66 800
66 1000
66 1200
66 1400
66 1600
66 1800
66 2000
66 2200
66 2400
66 2600
66 2800
66 3000
66 3200
66 3400
Epoch 66: train loss: 0.9095773100852966; test loss: 0.934589445590972
9
Epoch 66: train accuracy: 0.827615298087739; test accuracy: 0.80877390
```

```
32620922
67 0
67 200
67 400
67 600
67 800
67 1000
67 1200
67 1400
67 1600
67 1800
67 2000
67 2200
67 2400
67 2600
67 2800
67 3000
67 3200
67 3400
Epoch 67: train loss: 0.9093441367149353; test loss: 0.934848248958587
6
Epoch 67: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
68 0
68 200
68 400
68 600
68 800
68 1000
68 1200
68 1400
68 1600
68 1800
68 2000
68 2200
68 2400
68 2600
68 2800
68 3000
68 3200
68 3400
Epoch 68: train loss: 0.9087425470352173; test loss: 0.934272766113281
2
Epoch 68: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
69 0
69 200
69 400
69 600
69 800
```

```
69 1000
69 1200
69 1400
69 1600
69 1800
69 2000
69 2200
69 2400
69 2600
69 2800
69 3000
69 3200
69 3400
Epoch 69: train loss: 0.9085978865623474; test loss: 0.934211194515228
3
Epoch 69: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
70 0
70 200
70 400
70 600
70 800
70 1000
70 1200
70 1400
70 1600
70 1800
70 2000
70 2200
70 2400
70 2600
70 2800
70 3000
70 3200
70 3400
Epoch 70: train loss: 0.9089676141738892; test loss: 0.934979796409606
9
Epoch 70: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
71 0
71 200
71 400
71 600
71 800
71 1000
71 1200
71 1400
71 1600
71 1800
71 2000
```

```
71 2200
71 2400
71 2600
71 2800
71 3000
71 3200
71 3400
Epoch 71: train loss: 0.9083985686302185; test loss: 0.934258878231048
6
Epoch 71: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
72 0
72 200
72 400
72 600
72 800
72 1000
72 1200
72 1400
72 1600
72 1800
72 2000
72 2200
72 2400
72 2600
72 2800
72 3000
72 3200
72 3400
Epoch 72: train loss: 0.9084873795509338; test loss: 0.934594094753265
4
Epoch 72: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
73 0
73 200
73 400
73 600
73 800
73 1000
73 1200
73 1400
73 1600
73 1800
73 2000
73 2200
73 2400
73 2600
73 2800
73 3000
73 3200
```

```
73 3400
Epoch 73: train loss: 0.9082058668136597; test loss: 0.934110224246978
8
Epoch 73: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
74 0
74 200
74 400
74 600
74 800
74 1000
74 1200
74 1400
74 1600
74 1800
74 2000
74 2200
74 2400
74 2600
74 2800
74 3000
74 3200
74 3400
Epoch 74: train loss: 0.9075556993484497; test loss: 0.933820128440856
9
Epoch 74: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
75 0
75 200
75 400
75 600
75 800
75 1000
75 1200
75 1400
75 1600
75 1800
75 2000
75 2200
75 2400
75 2600
75 2800
75 3000
75 3200
75 3400
Epoch 75: train loss: 0.9089787006378174; test loss: 0.934967756271362
3
Epoch 75: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
76 0
```

```
76 200
76 400
76 600
76 800
76 1000
76 1200
76 1400
76 1600
76 1800
76 2000
76 2200
76 2400
76 2600
76 2800
76 3000
76 3200
76 3400
Epoch 76: train loss: 0.9086042642593384; test loss: 0.934767603874206
5
Epoch 76: train accuracy: 0.8262092238470191; test accuracy: 0.8076490
438695163
77 0
77 200
77 400
77 600
77 800
77 1000
77 1200
77 1400
77 1600
77 1800
77 2000
77 2200
77 2400
77 2600
77 2800
77 3000
77 3200
77 3400
Epoch 77: train loss: 0.908856987953186; test loss: 0.9336532950401306
Epoch 77: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
78 0
78 200
78 400
78 600
78 800
78 1000
78 1200
78 1400
```

```
78 1600
78 1800
78 2000
78 2200
78 2400
78 2600
78 2800
78 3000
78 3200
78 3400
Epoch 78: train loss: 0.908805251121521; test loss: 0.9333786368370056
Epoch 78: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
79 0
79 200
79 400
79 600
79 800
79 1000
79 1200
79 1400
79 1600
79 1800
79 2000
79 2200
79 2400
79 2600
79 2800
79 3000
79 3200
79 3400
Epoch 79: train loss: 0.9082248210906982; test loss: 0.933830797672271
7
Epoch 79: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
80 0
80 200
80 400
80 600
80 800
80 1000
80 1200
80 1400
80 1600
80 1800
80 2000
80 2200
80 2400
80 2600
80 2800
```

```
80 3000
80 3200
80 3400
Epoch 80: train loss: 0.9081640243530273; test loss: 0.933544337749481
2
Epoch 80: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
81 0
81 200
81 400
81 600
81 800
81 1000
81 1200
81 1400
81 1600
81 1800
81 2000
81 2200
81 2400
81 2600
81 2800
81 3000
81 3200
81 3400
Epoch 81: train loss: 0.9079707264900208; test loss: 0.934569060802459
7
Epoch 81: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
82 0
82 200
82 400
82 600
82 800
82 1000
82 1200
82 1400
82 1600
82 1800
82 2000
82 2200
82 2400
82 2600
82 2800
82 3000
82 3200
82 3400
Epoch 82: train loss: 0.9078956842422485; test loss: 0.933340191841125
5
Epoch 82: train accuracy: 0.827615298087739; test accuracy: 0.80877390
```

```
32620922
83 0
83 200
83 400
83 600
83 800
83 1000
83 1200
83 1400
83 1600
83 1800
83 2000
83 2200
83 2400
83 2600
83 2800
83 3000
83 3200
83 3400
Epoch 83: train loss: 0.9080818295478821; test loss: 0.934092104434967
Epoch 83: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
84 0
84 200
84 400
84 600
84 800
84 1000
84 1200
84 1400
84 1600
84 1800
84 2000
84 2200
84 2400
84 2600
84 2800
84 3000
84 3200
84 3400
Epoch 84: train loss: 0.9083895683288574; test loss: 0.93422532081604
Epoch 84: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
85 0
85 200
85 400
85 600
85 800
85 1000
85 1200
```

```
85 1400
85 1600
85 1800
85 2000
85 2200
85 2400
85 2600
85 2800
85 3000
85 3200
85 3400
Epoch 85: train loss: 0.9075844883918762; test loss: 0.934096693992614
7
Epoch 85: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
86 0
86 200
86 400
86 600
86 800
86 1000
86 1200
86 1400
86 1600
86 1800
86 2000
86 2200
86 2400
86 2600
86 2800
86 3000
86 3200
86 3400
Epoch 86: train loss: 0.9078280329704285; test loss: 0.933800816535949
7
Epoch 86: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
87 0
87 200
87 400
87 600
87 800

87 1000
87 1200
87 1400
87 1600
87 1800
87 2000
87 2200
```

```
87 2400
87 2600
87 2800
87 3000
87 3200
87 3400
Epoch 87: train loss: 0.9076029658317566; test loss: 0.933329105377197
3
Epoch 87: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
88 0
88 200
88 400
88 600
88 800
88 1000
88 1200
88 1400
88 1600
88 1800
88 2000
88 2200
88 2400
88 2600
88 2800
88 3000
88 3200
88 3400
Epoch 88: train loss: 0.9074360728263855; test loss: 0.934195876121521
Epoch 88: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
89 0
89 200
89 400
89 600
89 800
89 1000
89 1200
89 1400
89 1600
89 1800
89 2000
89 2200
89 2400
89 2600
89 2800
89 3000
89 3200
89 3400
Epoch 89: train loss: 0.908097505569458; test loss: 0.9336177110671997
```

```
Epoch 89: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
90 0
90 200
90 400
90 600
90 800
90 1000
90 1200
90 1400
90 1600
90 1800
90 2000
90 2200
90 2400
90 2600
90 2800
90 3000
90 3200
90 3400
Epoch 90: train loss: 0.9085283279418945; test loss: 0.933595001697540
3
Epoch 90: train accuracy: 0.827615298087739; test accuracy: 0.80877390
32620922
91 0
91 200
91 400
91 600
91 800
91 1000
91 1200
91 1400
91 1600
91 1800
91 2000
91 2200
91 2400
91 2600
91 2800
91 3000
91 3200
91 3400
Epoch 91: train loss: 0.9110337495803833; test loss: 0.936434924602508
5
Epoch 91: train accuracy: 0.8256467941507312; test accuracy: 0.8065241
844769404
92 0
92 200
92 400
92 600
```

```
92 800
92 1000
92 1200
92 1400
92 1600
92 1800
92 2000
92 2200
92 2400
92 2600
92 2800
92 3000
92 3200
92 3400
Epoch 92: train loss: 0.9146702885627747; test loss: 0.936162114143371
6
Epoch 92: train accuracy: 0.8256467941507312; test accuracy: 0.8065241
844769404
93 0
93 200
93 400
93 600
93 800
93 1000
93 1200
93 1400
93 1600
93 1800
93 2000
93 2200
93 2400
93 2600
93 2800
93 3000
93 3200
93 3400
Epoch 93: train loss: 0.9138516187667847; test loss: 0.936686038970947
3
Epoch 93: train accuracy: 0.8245219347581553; test accuracy: 0.8042744
656917885
94 0
94 200
94 400
94 600
94 800
94 1000
94 1200
94 1400
94 1600
94 1800
```

```
94 2000
94 2200
94 2400
94 2600
94 2800
94 3000
94 3200
94 3400
Epoch 94: train loss: 0.9350380301475525; test loss: 0.9384765625
Epoch 94: train accuracy: 0.8245219347581553; test accuracy: 0.8042744
656917885
95 0
95 200
95 400
95 600
95 800
95 1000
95 1200
95 1400
95 1600
95 1800
95 2000
95 2200
95 2400
95 2600
95 2800
95 3000
95 3200
95 3400
Epoch 95: train loss: 0.9102279543876648; test loss: 0.938823461532592
8
Epoch 95: train accuracy: 0.8245219347581553; test accuracy: 0.8065241
844769404
96 0
96 200
96 400
96 600
96 800
96 1000
96 1200
96 1400
96 1600
96 1800
96 2000
96 2200
96 2400
96 2600
96 2800
96 3000
96 3200
```

```
96 3400
Epoch 96: train loss: 0.9234780669212341; test loss: 0.940302789211273
2
Epoch 96: train accuracy: 0.8239595050618672; test accuracy: 0.8042744
656917885
97 0
97 200
97 400
97 600
97 800
97 1000
97 1200
97 1400
97 1600
97 1800
97 2000
97 2200
97 2400
97 2600
97 2800
97 3000
97 3200
97 3400
Epoch 97: train loss: 0.9267202615737915; test loss: 0.939455807209014
9
Epoch 97: train accuracy: 0.8225534308211474; test accuracy: 0.8053993
250843644
98 0
98 200
98 400
98 600
98 800
98 1000
98 1200
98 1400
98 1600
98 1800
98 2000
98 2200
98 2400
98 2600
98 2800
98 3000
98 3200
98 3400
Epoch 98: train loss: 0.9212868809700012; test loss: 0.935420691967010
5
Epoch 98: train accuracy: 0.8250843644544432; test accuracy: 0.8065241
844769404
99 0
```

```
99 200
99 400
99 600
99 800
99 1000
99 1200
99 1400
99 1600
99 1800
99 2000
99 2200
99 2400
99 2600
99 2800
99 3000
99 3200
99 3400
Epoch 99: train loss: 0.9054186940193176; test loss: 0.928720116615295
4
Epoch 99: train accuracy: 0.8262092238470191; test accuracy: 0.8143982
002249719
100 0
100 200
100 400
100 600
100 800
100 1000
100 1200
100 1400
100 1600
100 1800
100 2000
100 2200
100 2400
100 2600
100 2800
100 3000
100 3200
100 3400
Epoch 100: train loss: 0.9054793119430542; test loss: 0.92725414037704
47
Epoch 100: train accuracy: 0.827334083239595; test accuracy: 0.8166479
190101237
101 0
101 200
101 400
101 600
101 800
101 1000
101 1200
```

```
101 1400
101 1600
101 1800
101 2000
101 2200
101 2400
101 2600
101 2800
101 3000
101 3200
101 3400
Epoch 101: train loss: 0.9061421155929565; test loss: 0.93337506055831
91
Epoch 101: train accuracy: 0.8253655793025871; test accuracy: 0.809898
7626546682
102 0
102 200
102 400
102 600
102 800
102 1000
102 1200
102 1400
102 1600
102 1800
102 2000
102 2200
102 2400
102 2600
102 2800
102 3000
102 3200
102 3400
Epoch 102: train loss: 0.9024611115455627; test loss: 0.92913460731506
35
Epoch 102: train accuracy: 0.827334083239595; test accuracy: 0.8143982
002249719
103 0
103 200
103 400
103 600
103 800
103 1000
103 1200
103 1400
103 1600
103 1800
103 2000
103 2200
103 2400
```

```
103 2600
103 2800
103 3000
103 3200
103 3400
Epoch 103: train loss: 0.9043989181518555; test loss: 0.93025976419448
85
Epoch 103: train accuracy: 0.827334083239595; test accuracy: 0.8121484
8143982
104 0
104 200
104 400
104 600
104 800
104 1000
104 1200
104 1400
104 1600
104 1800
104 2000
104 2200
104 2400
104 2600
104 2800
104 3000
104 3200
104 3400
Epoch 104: train loss: 0.9018111824989319; test loss: 0.93249541521072
39
Epoch 104: train accuracy: 0.8253655793025871; test accuracy: 0.807649
0438695163
105 0
105 200
105 400
105 600
105 800
105 1000
105 1200
105 1400
105 1600
105 1800
105 2000
105 2200
105 2400
105 2600
105 2800
105 3000
105 3200
105 3400
Epoch 105: train loss: 0.903436541557312; test loss: 0.931023001670837
```

```
4
Epoch 105: train accuracy: 0.8262092238470191; test accuracy: 0.812148
48143982
106 0
106 200
106 400
106 600
106 800
106 1000
106 1200
106 1400
106 1600
106 1800
106 2000
106 2200
106 2400
106 2600
106 2800
106 3000
106 3200
106 3400
Epoch 106: train loss: 0.9024113416671753; test loss: 0.92733865976333
62
Epoch 106: train accuracy: 0.827334083239595; test accuracy: 0.8143982
002249719
107 0
107 200
107 400
107 600
107 800
107 1000
107 1200
107 1400
107 1600
107 1800
107 2000
107 2200
107 2400
107 2600
107 2800
107 3000
107 3200
107 3400
Epoch 107: train loss: 0.9011703133583069; test loss: 0.92752534151077
27
Epoch 107: train accuracy: 0.828458942632171; test accuracy: 0.8143982
002249719
108 0
108 200
108 400
```

```
108 600
108 800
108 1000
108 1200
108 1400
108 1600
108 1800
108 2000
108 2200
108 2400
108 2600
108 2800
108 3000
108 3200
108 3400
Epoch 108: train loss: 0.9018865823745728; test loss: 0.92735588550567
63
Epoch 108: train accuracy: 0.828458942632171; test accuracy: 0.8143982
002249719
109 0
109 200
109 400
109 600
109 800
109 1000
109 1200
109 1400
109 1600
109 1800
109 2000
109 2200
109 2400
109 2600
109 2800
109 3000
109 3200
109 3400
Epoch 109: train loss: 0.9020193815231323; test loss: 0.92841064929962
16
Epoch 109: train accuracy: 0.827334083239595; test accuracy: 0.8143982
002249719
110 0
110 200
110 400
110 600
110 800
110 1000
110 1200
110 1400
110 1600
```

```
110 1800
110 2000
110 2200
110 2400
110 2600
110 2800
110 3000
110 3200
110 3400
Epoch 110: train loss: 0.9013345241546631; test loss: 0.92787641286849
98
Epoch 110: train accuracy: 0.828458942632171; test accuracy: 0.8143982
002249719
111 0
111 200
111 400
111 600
111 800
111 1000
111 1200
111 1400
111 1600
111 1800
111 2000
111 2200
111 2400
111 2600
111 2800
111 3000
111 3200
111 3400
Epoch 111: train loss: 0.9017438888549805; test loss: 0.92777884006500
24
Epoch 111: train accuracy: 0.828458942632171; test accuracy: 0.8143982
002249719
112 0
112 200
112 400
112 600
112 800
112 1000
112 1200
112 1400
112 1600
112 1800
112 2000
112 2200
112 2400
112 2600
112 2800
```

```
112 3000
112 3200
112 3400
Epoch 112: train loss: 0.9018125534057617; test loss: 0.92807430028915
4
Epoch 112: train accuracy: 0.828458942632171; test accuracy: 0.8143982
002249719
113 0
113 200
113 400
113 600
113 800
113 1000
113 1200
113 1400
113 1600
113 1800
113 2000
113 2200
113 2400
113 2600
113 2800
113 3000
113 3200
113 3400
Epoch 113: train loss: 0.901426374912262; test loss: 0.927426159381866
5
Epoch 113: train accuracy: 0.828458942632171; test accuracy: 0.8143982
002249719
114 0
114 200
114 400
114 600
114 800
114 1000
114 1200
114 1400
114 1600
114 1800
114 2000
114 2200
114 2400
114 2600
114 2800
114 3000
114 3200
114 3400
Epoch 114: train loss: 0.9017579555511475; test loss: 0.92849397659301
76
Epoch 114: train accuracy: 0.828458942632171; test accuracy: 0.8143982
```

```
002249719
115 0
115 200
115 400
115 600
115 800

115 1000
115 1200
115 1400
115 1600
115 1800
115 2000
115 2200
115 2400
115 2600
115 2800
115 3000
115 3200
115 3400
Epoch 115: train loss: 0.901252269744873; test loss: 0.927676677703857
4
Epoch 115: train accuracy: 0.828458942632171; test accuracy: 0.8143982
002249719
116 0
116 200
116 400
116 600
116 800
116 1000
116 1200
116 1400
116 1600
116 1800
116 2000
116 2200
116 2400
116 2600
116 2800
116 3000
116 3200
116 3400
Epoch 116: train loss: 0.9017642140388489; test loss: 0.92940676212310
79
Epoch 116: train accuracy: 0.829021372328459; test accuracy: 0.8143982
002249719
117 0
117 200
117 400
117 600
```

```
117 800
117 1000
117 1200
117 1400
117 1600
117 1800
117 2000
117 2200
117 2400
117 2600
117 2800
117 3000
117 3200
117 3400
Epoch 117: train loss: 0.9024845957756042; test loss: 0.93111395835876
46
Epoch 117: train accuracy: 0.8295838020247469; test accuracy: 0.813273
340832396
118 0
118 200
118 400
118 600
118 800
118 1000
118 1200
118 1400
118 1600
118 1800
118 2000
118 2200
118 2400
118 2600
118 2800
118 3000
118 3200
118 3400
Epoch 118: train loss: 0.9006943106651306; test loss: 0.92458534240722
66
Epoch 118: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
119 0
119 200
119 400
119 600
119 800
119 1000
119 1200
119 1400
119 1600
119 1800
```

```
119 2000
119 2200
119 2400
119 2600
119 2800
119 3000
119 3200
119 3400
Epoch 119: train loss: 0.9013043642044067; test loss: 0.92446094751358
03
Epoch 119: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
120 0
120 200
120 400
120 600
120 800
120 1000
120 1200
120 1400
120 1600
120 1800
120 2000
120 2200
120 2400
120 2600
120 2800
120 3000
120 3200
120 3400
Epoch 120: train loss: 0.9016690254211426; test loss: 0.92462009191513
06
Epoch 120: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
121 0
121 200
121 400
121 600
121 800
121 1000
121 1200
121 1400
121 1600
121 1800
121 2000
121 2200
121 2400
121 2600
121 2800
121 3000
```

```
121 3200
121 3400
Epoch 121: train loss: 0.9010124206542969; test loss: 0.92466121912002
56
Epoch 121: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
122 0
122 200
122 400
122 600
122 800
122 1000
122 1200
122 1400
122 1600
122 1800
122 2000
122 2200
122 2400
122 2600
122 2800
122 3000
122 3200
122 3400
Epoch 122: train loss: 0.9012454152107239; test loss: 0.92456960678100
59
Epoch 122: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
123 0
123 200
123 400
123 600
123 800
123 1000
123 1200
123 1400
123 1600
123 1800
123 2000
123 2200
123 2400
123 2600
123 2800
123 3000
123 3200
123 3400
Epoch 123: train loss: 0.9010983109474182; test loss: 0.92440050840377
81
Epoch 123: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
```

```
124 0
124 200
124 400
124 600
124 800
124 1000
124 1200
124 1400
124 1600
124 1800
124 2000
124 2200
124 2400
124 2600
124 2800
124 3000
124 3200
124 3400
Epoch 124: train loss: 0.9008389115333557; test loss: 0.92420709133148
19
Epoch 124: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
125 0
125 200
125 400
125 600
125 800
125 1000
125 1200
125 1400
125 1600
125 1800
125 2000
125 2200
125 2400
125 2600
125 2800
125 3000
125 3200
125 3400
Epoch 125: train loss: 0.9019065499305725; test loss: 0.92437964677810
67
Epoch 125: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
126 0
126 200
126 400
126 600
126 800
126 1000
```

```
126 1200
126 1400
126 1600
126 1800
126 2000
126 2200
126 2400
126 2600
126 2800
126 3000
126 3200
126 3400
Epoch 126: train loss: 0.9019588828086853; test loss: 0.92551422119140
62
Epoch 126: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
127 0
127 200
127 400
127 600
127 800
127 1000
127 1200
127 1400
127 1600
127 1800
127 2000
127 2200
127 2400
127 2600
127 2800
127 3000
127 3200
127 3400
Epoch 127: train loss: 0.9026527404785156; test loss: 0.92779862880706
79
Epoch 127: train accuracy: 0.8295838020247469; test accuracy: 0.815523
0596175478
128 0
128 200
128 400
128 600
128 800
128 1000
128 1200
128 1400
128 1600
128 1800
128 2000
128 2200
```

```
128 2400
128 2600
128 2800
128 3000
128 3200
128 3400
Epoch 128: train loss: 0.9006547331809998; test loss: 0.92528218030929
57
Epoch 128: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
129 0
129 200
129 400
129 600
129 800
129 1000
129 1200
129 1400
129 1600
129 1800
129 2000
129 2200
129 2400
129 2600
129 2800
129 3000
129 3200
129 3400
Epoch 129: train loss: 0.9006768465042114; test loss: 0.92479175329208
37
Epoch 129: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
130 0
130 200
130 400
130 600
130 800
130 1000
130 1200
130 1400
130 1600
130 1800
130 2000
130 2200
130 2400
130 2600
130 2800
130 3000
130 3200
130 3400
```

```
Epoch 130: train loss: 0.9013501405715942; test loss: 0.92495113611221
31
Epoch 130: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
131 0
131 200
131 400
131 600
131 800
131 1000
131 1200
131 1400
131 1600
131 1800
131 2000
131 2200
131 2400
131 2600
131 2800
131 3000
131 3200
131 3400
Epoch 131: train loss: 0.9008065462112427; test loss: 0.92462593317031
86
Epoch 131: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
132 0
132 200
132 400
132 600
132 800
132 1000
132 1200
132 1400
132 1600
132 1800
132 2000
132 2200
132 2400
132 2600
132 2800
132 3000
132 3200
132 3400
Epoch 132: train loss: 0.9017156958580017; test loss: 0.92473435401916
5
Epoch 132: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
133 0
133 200
```

```
133 400
133 600
133 800
133 1000
133 1200
133 1400
133 1600
133 1800
133 2000
133 2200
133 2400
133 2600
133 2800
133 3000
133 3200
133 3400
Epoch 133: train loss: 0.9012858271598816; test loss: 0.92447340488433
84
Epoch 133: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
134 0
134 200
134 400
134 600
134 800
134 1000
134 1200
134 1400
134 1600
134 1800
134 2000
134 2200
134 2400
134 2600
134 2800
134 3000
134 3200
134 3400
Epoch 134: train loss: 0.9011601209640503; test loss: 0.92398667335510
25
Epoch 134: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
135 0
135 200
135 400
135 600
135 800
135 1000
135 1200
135 1400
```

```
135 1600
135 1800
135 2000
135 2200
135 2400
135 2600
135 2800
135 3000
135 3200
135 3400
Epoch 135: train loss: 0.9015697836875916; test loss: 0.92414557933807
37
Epoch 135: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
136 0
136 200
136 400
136 600
136 800
136 1000
136 1200
136 1400
136 1600
136 1800
136 2000
136 2200
136 2400
136 2600
136 2800
136 3000
136 3200
136 3400
Epoch 136: train loss: 0.9020954966545105; test loss: 0.92743086814880
37
Epoch 136: train accuracy: 0.8307086614173228; test accuracy: 0.815523
0596175478
137 0
137 200
137 400
137 600
137 800
137 1000
137 1200
137 1400
137 1600
137 1800
137 2000
137 2200
137 2400
137 2600
```

```
137 2800
137 3000
137 3200
137 3400
Epoch 137: train loss: 0.9012553691864014; test loss: 0.92667895555496
22
Epoch 137: train accuracy: 0.8304274465691789; test accuracy: 0.814398
2002249719
138 0
138 200
138 400
138 600
138 800
138 1000
138 1200
138 1400
138 1600
138 1800
138 2000
138 2200
138 2400
138 2600
138 2800
138 3000
138 3200
138 3400
Epoch 138: train loss: 0.9019836783409119; test loss: 0.92482089996337
89
Epoch 138: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
139 0
139 200
139 400
139 600
139 800
139 1000
139 1200
139 1400
139 1600
139 1800
139 2000
139 2200
139 2400
139 2600
139 2800
139 3000
139 3200
139 3400
Epoch 139: train loss: 0.9010650515556335; test loss: 0.92392063140869
14
```

```
Epoch 139: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
140 0
140 200
140 400
140 600
140 800
140 1000
140 1200
140 1400
140 1600
140 1800
140 2000
140 2200
140 2400
140 2600
140 2800
140 3000
140 3200
140 3400
Epoch 140: train loss: 0.9012799263000488; test loss: 0.92450588941574
1
Epoch 140: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
141 0
141 200
141 400
141 600
141 800
141 1000
141 1200
141 1400
141 1600
141 1800
141 2000
141 2200
141 2400
141 2600
141 2800
141 3000
141 3200
141 3400
Epoch 141: train loss: 0.9013238549232483; test loss: 0.92500782012939
45
Epoch 141: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
142 0
142 200
142 400
142 600
```

```
142 800

142 1000
142 1200
142 1400
142 1600
142 1800
142 2000
142 2200
142 2400
142 2600
142 2800
142 3000
142 3200
142 3400
Epoch 142: train loss: 0.9006259441375732; test loss: 0.92417573928833
01
Epoch 142: train accuracy: 0.8318335208098988; test accuracy: 0.817772
7784026997
143 0
143 200
143 400
143 600
143 800
143 1000
143 1200
143 1400
143 1600
143 1800
143 2000
143 2200
143 2400
143 2600
143 2800
143 3000
143 3200
143 3400
Epoch 143: train loss: 0.9012117385864258; test loss: 0.92288339138031
01
Epoch 143: train accuracy: 0.8326771653543307; test accuracy: 0.818897
6377952756
144 0
144 200
144 400
144 600
144 800
144 1000
144 1200
144 1400
144 1600
```

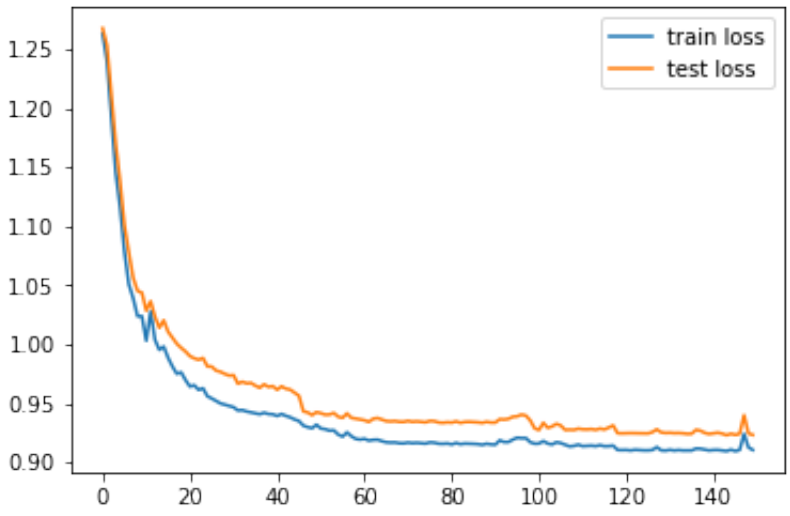
```
144 1800
144 2000
144 2200
144 2400
144 2600
144 2800
144 3000
144 3200
144 3400
Epoch 144: train loss: 0.9018985033035278; test loss: 0.92411464452743
53
Epoch 144: train accuracy: 0.8326771653543307; test accuracy: 0.818897
6377952756
145 0
145 200
145 400
145 600
145 800
145 1000
145 1200
145 1400
145 1600
145 1800
145 2000
145 2200
145 2400
145 2600
145 2800
145 3000
145 3200
145 3400
Epoch 145: train loss: 0.9022480845451355; test loss: 0.92319840192794
8
Epoch 145: train accuracy: 0.8326771653543307; test accuracy: 0.818897
6377952756
146 0
146 200
146 400
146 600
146 800
146 1000
146 1200
146 1400
146 1600
146 1800
146 2000
146 2200
146 2400
146 2600
146 2800
```

```
146 3000
146 3200
146 3400
Epoch 146: train loss: 0.9038940668106079; test loss: 0.92404067516326
9
Epoch 146: train accuracy: 0.8326771653543307; test accuracy: 0.818897
6377952756
147 0
147 200
147 400
147 600
147 800
147 1000
147 1200
147 1400
147 1600
147 1800
147 2000
147 2200
147 2400
147 2600
147 2800
147 3000
147 3200
147 3400
Epoch 147: train loss: 0.9231297373771667; test loss: 0.93981742858886
72
Epoch 147: train accuracy: 0.8152418447694039; test accuracy: 0.802024
7469066367
148 0
148 200
148 400
148 600
148 800
148 1000
148 1200
148 1400
148 1600
148 1800
148 2000
148 2200
148 2400
148 2600
148 2800
148 3000
148 3200
148 3400
Epoch 148: train loss: 0.905107855796814; test loss: 0.924313247203826
9
Epoch 148: train accuracy: 0.8326771653543307; test accuracy: 0.821147
```

```
3565804275
149 0
149 200
149 400
149 600
149 800
149 1000
149 1200
149 1400
149 1600
149 1800
149 2000
149 2200
149 2400
149 2600
149 2800
149 3000
149 3200
149 3400
Epoch 149: train loss: 0.9063147306442261; test loss: 0.92315536737442
02
Epoch 149: train accuracy: 0.8326771653543307; test accuracy: 0.821147
3565804275
```

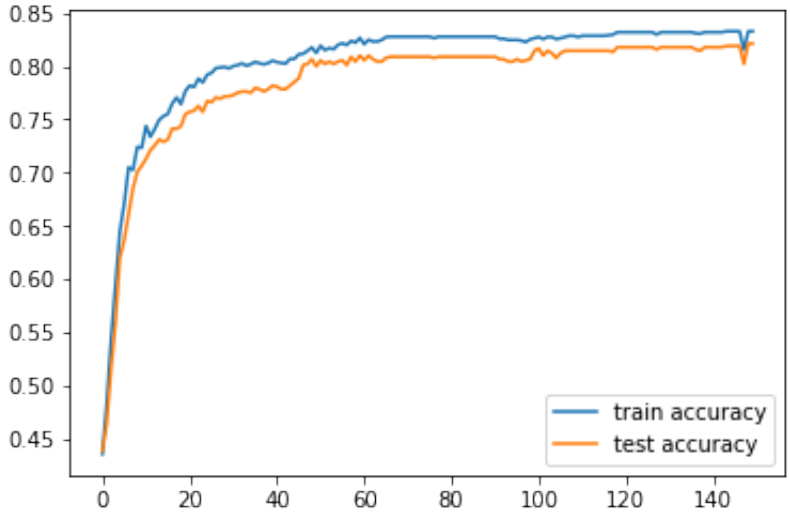
In [8]:
```
plt.plot(train_losses, label = "train loss")
plt.plot(test_losses, label = "test loss")
plt.legend()
```

Out[8]: <matplotlib.legend.Legend at 0x7f70300cb358>



In [9]:
```
plt.plot(train_accuracies, label = "train accuracy")
plt.plot(test_accuracies, label = "test accuracy")
plt.legend()
```

Out[9]: <matplotlib.legend.Legend at 0x7f6e44372ef0>



In [10]:
```
torch.save(combined_net.state_dict(), "data/combined_net_2conv")
```

In [ ]: