

## P2\_Q2\_B

November 15, 2022

```
[7]: import torch
import torch.nn as nn
import torch.nn.functional as F
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

```
[8]: class Net(nn.Module):

    def __init__(self):
        super(Net, self).__init__()
        self.fc1 = nn.Linear(2, 32)
        self.fc2 = nn.Linear(32, 32)
        #self.fc3 = nn.Linear(256, 256)
        #self.fc4 = nn.Linear(128, 128)
        #self.fc5 = nn.Linear(128, 128)
        #self.fc6 = nn.Linear(128, 128)
        self.fc7 = nn.Linear(32, 2)

    def forward(self, x):
        x = F.relu(self.fc1(x))
        x = F.relu(self.fc2(x))
        #x = F.relu(self.fc3(x))
        #x = F.relu(self.fc4(x))
        #x = F.relu(self.fc5(x))
        #x = F.relu(self.fc6(x))
        x = self.fc7(x)
        return F.log_softmax(x)
        #return F.softmax(x)
```

```
[9]: def plot_data(X, y, filename):
    plt.scatter(X[:, 0], X[:, 1], c=y, cmap=plt.cm.Spectral, s = 1)
    plt.savefig(filename)
    plt.close()

def plot_decision_boundary(clf, X, y, filename):
    # Set min and max values and give it some padding
```

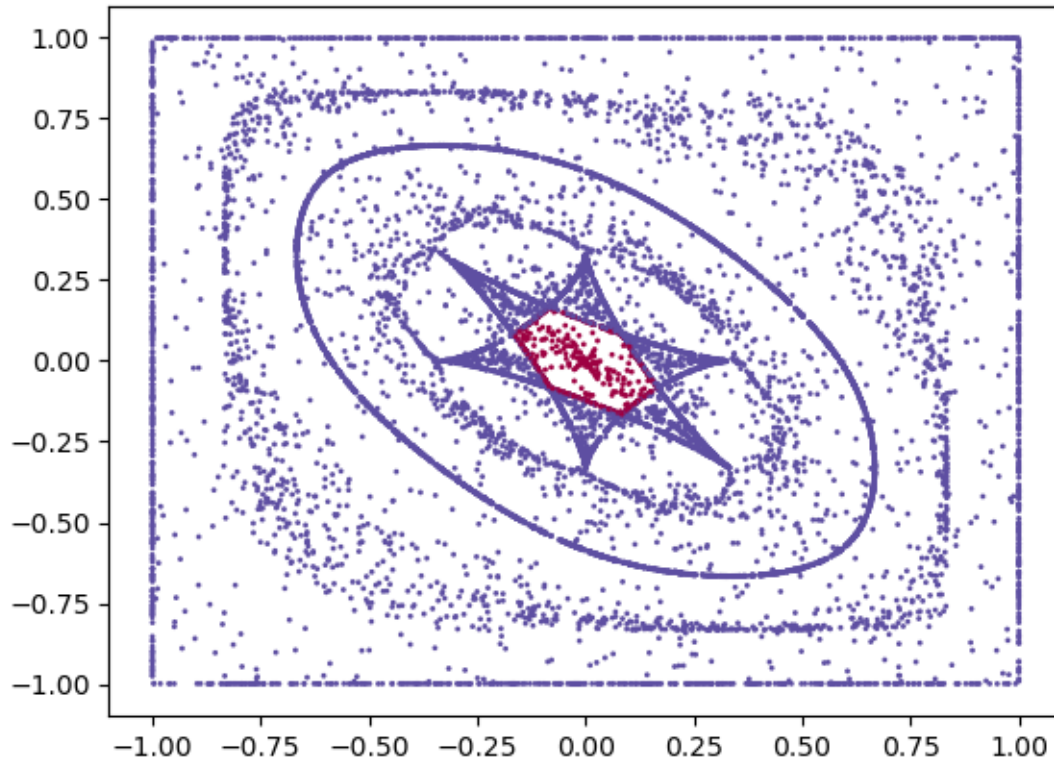
```

#x_min, x_max = X[:, 0].min() - .1, X[:, 0].max() + .1
#y_min, y_max = X[:, 1].min() - .1, X[:, 1].max() + .1
x_min, x_max = -1, 1
y_min, y_max = -1, 1
h = 0.01
# Generate a grid of points with distance h between them
xx, yy = np.meshgrid(np.arange(x_min, x_max, h), np.arange(y_min, y_max, h))
# Predict the function value for the whole grid
#Z = clf.predict(np.c_[xx.ravel(), yy.ravel()])
X_out = net(torch.tensor(np.c_[xx.ravel(), yy.ravel()], dtype = torch.
↪float))
Z = X_out.data.max(1)[1]
# Z.shape
Z = Z.reshape(xx.shape)
# Plot the contour and training examples
plt.contourf(xx, yy, Z, cmap=plt.cm.Spectral)
plt.scatter(X[:, 0], X[:, 1], c=y, cmap=plt.cm.Spectral, s = 1)
plt.savefig(filename)
plt.close()

data = pd.read_csv("FeedForward_Data_hexa.csv") # UPDATE THE FILE NAME AND PATH_
↪TO MATCH YOUR REQUIREMENT
X = data.values[:, 0:2] # Take only the first two features.
X = torch.tensor(X, dtype = torch.float)
y = data.values[:, 2]
y = torch.tensor(y, dtype = torch.long)
plt.scatter(X[:, 0], X[:, 1], c=y, cmap=plt.cm.Spectral, s = 1)

```

[9]: <matplotlib.collections.PathCollection at 0x17ae2b7cbe0>



```
[4]: ### train
net = Net()

# create a stochastic gradient descent optimizer
learning_rate = 0.01
optimizer = torch.optim.Adam(net.parameters(), lr=learning_rate)
#optimizer = torch.optim.SGD(net.parameters(), lr=learning_rate, momentum=0.9)

# create a loss function
criterion = nn.CrossEntropyLoss()
#criterion = nn.NLLLoss()

#nepochs = 600
nepochs = 10000
#10000
data, target = X, y

for epoch in range(nepochs):
    # adjust learning rate if desired
    # if epoch % 3000 == 0 and epoch <= 24000:
    #     for g in optimizer.param_groups:
    #         g['lr'] = g['lr']/2
```

```

optimizer.zero_grad()
# forward propagate
net_out = net(data)
# compute loss
loss = criterion(net_out, target)

# backpropagate
loss.backward()
# update parameters
optimizer.step()
# print out report

if epoch % 10 == 0:
    print('Epoch ', epoch, 'Loss ', loss.item())
    #if(loss.item()<0.0001):
        #break
    net_out = net(data)
    pred = net_out.data.max(1)[1] # get the index of the max
    ↪log-probability
    correctidx = pred.eq(target.data)
    ncorrect = correctidx.sum()
    accuracy = ncorrect.item()/len(data)
    print('Training accuracy is ', accuracy)
    if (accuracy==1):
        break

```

C:\Users\aradh\AppData\Local\Temp\ipykernel\_57672\3878313576.py:21: UserWarning: Implicit dimension choice for log\_softmax has been deprecated. Change the call to include dim=X as an argument.

```
return F.log_softmax(x)
```

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Epoch 0 Loss 0.8406838774681091
Training accuracy is 0.05942453609796409
Epoch 10 Loss 0.2082149237394333
Training accuracy is 0.940575463902036
Epoch 20 Loss 0.24280154705047607
Training accuracy is 0.940575463902036
Epoch 30 Loss 0.18550577759742737
Training accuracy is 0.940575463902036
Epoch 40 Loss 0.16519393026828766
Training accuracy is 0.940575463902036
Epoch 50 Loss 0.14880849421024323
Training accuracy is 0.940575463902036
Epoch 60 Loss 0.1339007467031479
Training accuracy is 0.940575463902036
Epoch 70 Loss 0.12227896600961685
Training accuracy is 0.940575463902036
Epoch 80 Loss 0.11154074966907501

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Training accuracy is 0.940575463902036  
Epoch 90 Loss 0.10206683725118637  
Training accuracy is 0.940575463902036  
Epoch 100 Loss 0.09338100254535675  
Training accuracy is 0.940575463902036  
Epoch 110 Loss 0.08600346744060516  
Training accuracy is 0.940575463902036  
Epoch 120 Loss 0.08014880120754242  
Training accuracy is 0.9510930809105251  
Epoch 130 Loss 0.07572832703590393  
Training accuracy is 0.9557508827285703  
Epoch 140 Loss 0.07236476987600327  
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Epoch 150 Loss 0.06977000832557678  
Training accuracy is 0.9676207647810082  
Epoch 160 Loss 0.06769127398729324  
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Epoch 170 Loss 0.06580854207277298  
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Epoch 180 Loss 0.06467310339212418  
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Epoch 190 Loss 0.06298872828483582  
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Epoch 230 Loss 0.05950034037232399  
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Epoch 280 Loss 0.05643099173903465  
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Epoch 310 Loss 0.05553416535258293  
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Epoch 2080 Loss 0.035377830266952515  
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Epoch 2090 Loss 0.033172912895679474  
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Epoch 2100 Loss 0.03425729647278786  
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Epoch 2110 Loss 0.034339334815740585  
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Epoch 2120 Loss 0.032751500606536865  
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Epoch 2130 Loss 0.03567780554294586  
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Epoch 2140 Loss 0.034133415669202805  
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Epoch 2200 Loss 0.03244144469499588  
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Epoch 2220 Loss 0.032280512154102325  
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Epoch 2230 Loss 0.03569548949599266  
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Epoch 2240 Loss 0.03266742080450058

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Epoch 7160 Loss 0.025831906124949455  
Training accuracy is 0.9879047404402374  
Epoch 7170 Loss 0.023376960307359695  
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Training accuracy is 0.989257005484186  
Epoch 7190 Loss 0.023649035021662712  
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Epoch 7280 Loss 0.024418514221906662

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Training accuracy is 0.9900082638419352  
Epoch 9690 Loss 0.022426258772611618  
Training accuracy is 0.9907595221996844  
Epoch 9700 Loss 0.022091936320066452  
Training accuracy is 0.9906843963639096  
Epoch 9710 Loss 0.02602793090045452  
Training accuracy is 0.9864773495605138  
Epoch 9720 Loss 0.022221894934773445  
Training accuracy is 0.9910600255427842  
Epoch 9730 Loss 0.026242278516292572  
Training accuracy is 0.9900833896777101  
Epoch 9740 Loss 0.021942351013422012  
Training accuracy is 0.991210277214334  
Epoch 9750 Loss 0.02521471120417118  
Training accuracy is 0.9870783562467133  
Epoch 9760 Loss 0.022683436051011086  
Training accuracy is 0.9909097738712344  
Epoch 9770 Loss 0.024569183588027954  
Training accuracy is 0.9909848997070092  
Epoch 9780 Loss 0.023018252104520798  
Training accuracy is 0.9910600255427842  
Epoch 9790 Loss 0.02216833457350731  
Training accuracy is 0.9906843963639096  
Epoch 9800 Loss 0.028148243203759193  
Training accuracy is 0.9848997070092405  
Epoch 9810 Loss 0.021974312141537666  
Training accuracy is 0.9914356547216587  
Epoch 9820 Loss 0.025721462443470955  
Training accuracy is 0.9906843963639096  
Epoch 9830 Loss 0.021978572010993958  
Training accuracy is 0.9908346480354594  
Epoch 9840 Loss 0.025288812816143036  
Training accuracy is 0.987303733754038  
Epoch 9850 Loss 0.022627798840403557  
Training accuracy is 0.9906843963639096  
Epoch 9860 Loss 0.02381783165037632  
Training accuracy is 0.9913605288858839  
Epoch 9870 Loss 0.025973143056035042  
Training accuracy is 0.9910600255427842  
Epoch 9880 Loss 0.022753315046429634  
Training accuracy is 0.9901585155134851  
Epoch 9890 Loss 0.024769114330410957  
Training accuracy is 0.9887311246337616  
Epoch 9900 Loss 0.02188412845134735  
Training accuracy is 0.9910600255427842  
Epoch 9910 Loss 0.023882895708084106  
Training accuracy is 0.9911351513785591  
Epoch 9920 Loss 0.026443002745509148

```

Training accuracy is 0.9909097738712344
Epoch 9930 Loss 0.024677827954292297
Training accuracy is 0.9888813763053114
Epoch 9940 Loss 0.021909110248088837
Training accuracy is 0.9913605288858839
Epoch 9950 Loss 0.023738695308566093
Training accuracy is 0.9914356547216587
Epoch 9960 Loss 0.027674639597535133
Training accuracy is 0.9906092705281346
Epoch 9970 Loss 0.023708760738372803
Training accuracy is 0.9894823829915108
Epoch 9980 Loss 0.022481735795736313
Training accuracy is 0.9906843963639096
Epoch 9990 Loss 0.02214541658759117
Training accuracy is 0.991210277214334

Epoch 9350 Loss 0.022177480161190033 Training accuracy is 0.9916610322289835

```

```
[5]: plt.scatter(X[:, 0], X[:, 1], c=pred, cmap=plt.cm.Spectral, s = 1)
      plot_decision_boundary(net, X, y, 'P2_Q2_B.pdf')
```

```

C:\Users\aradh\AppData\Local\Temp\ipykernel_57672\3878313576.py:21: UserWarning:
Implicit dimension choice for log_softmax has been deprecated. Change the call
to include dim=X as an argument.
    return F.log_softmax(x)

```

```
[6]: plot_decision_boundary(net, X, y, 'P2_Q2_B')
```

```

C:\Users\aradh\AppData\Local\Temp\ipykernel_57672\3878313576.py:21: UserWarning:
Implicit dimension choice for log_softmax has been deprecated. Change the call
to include dim=X as an argument.
    return F.log_softmax(x)

```

```
[ ]:
```