P2_Q2_A

November 15, 2022

```python
[1]: 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
```

```python
[2]: class Net(nn.Module):

         def __init__(self):
             super(Net, self).__init__()
             self.fc1 = nn.Linear(2, 256)
             self.fc2 = nn.Linear(256, 256)
             #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(256, 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)
```

```python
[3]: 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
```
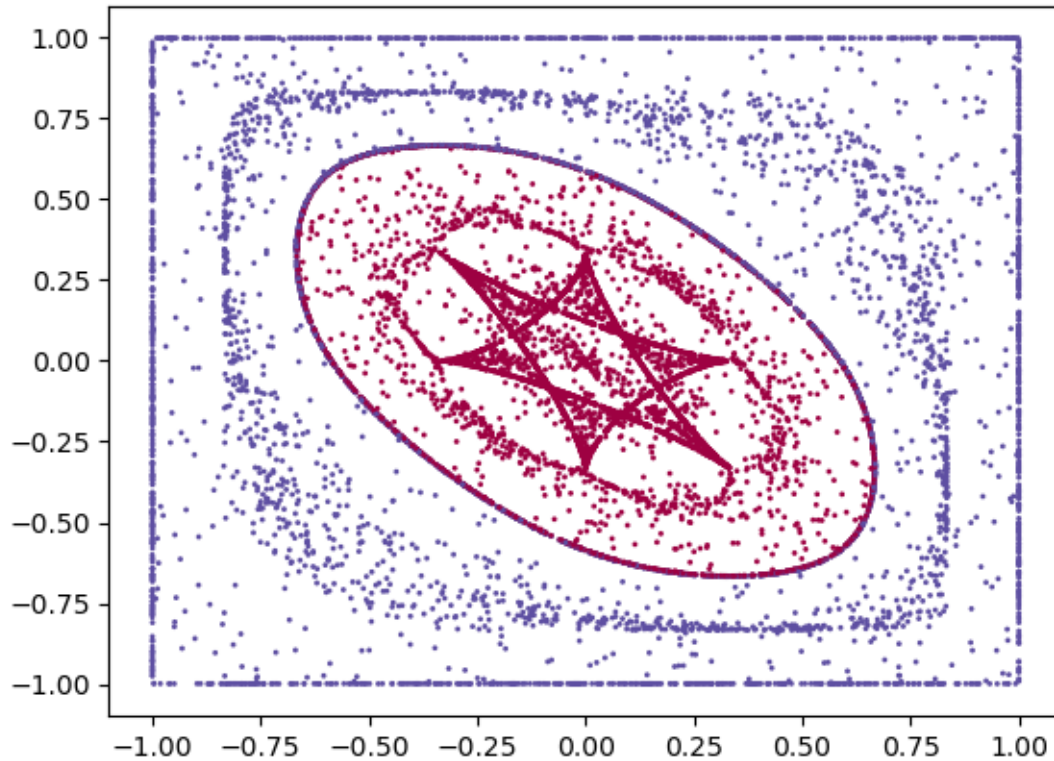
1

```python
    #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 gid
    #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_ellipse.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)
```

[3]: <matplotlib.collections.PathCollection at 0x156ebc45a00>

```
[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
```

```python
    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_53704\2298959118.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)

Epoch 0 Loss 0.6946420073509216
Training accuracy is 0.5565321914206296
Epoch 10 Loss 0.31295934319496155
Training accuracy is 0.8316430020283976
Epoch 20 Loss 0.22611896693706512
Training accuracy is 0.8807001727894223
Epoch 30 Loss 0.20691372454166412
Training accuracy is 0.8967019758094809
Epoch 40 Loss 0.19981667399406433
Training accuracy is 0.8980542408534294
Epoch 50 Loss 0.19721658527851105
Training accuracy is 0.8990308767185035
Epoch 60 Loss 0.1955541968345642
Training accuracy is 0.8991060025542784
Epoch 70 Loss 0.19441573321819305
Training accuracy is 0.8992562542258282
Epoch 80 Loss 0.19388648867607117

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Training accuracy is  0.8992562542258282
Epoch  90 Loss  0.19352933764457703
Training accuracy is  0.899481631733153
Epoch  100 Loss  0.19351603090763092
Training accuracy is  0.8990308767185035
Epoch  110 Loss  0.19392076134681702
Training accuracy is  0.9000826384193524
Epoch  120 Loss  0.19370155036449432
Training accuracy is  0.8991060025542784
Epoch  130 Loss  0.19268012046813965
Training accuracy is  0.9000075125835775
Epoch  140 Loss  0.1987382024526596
Training accuracy is  0.8988806250469537
Epoch  150 Loss  0.19485712051391602
Training accuracy is  0.9001577642551274
Epoch  160 Loss  0.19261278212070465
Training accuracy is  0.8990308767185035
Epoch  170 Loss  0.19186101853847504
Training accuracy is  0.8997070092404778
Epoch  180 Loss  0.19169537723064423
Training accuracy is  0.899481631733153
Epoch  190 Loss  0.19709515571594238
Training accuracy is  0.9043648110585231
Epoch  200 Loss  0.19125881791114807
Training accuracy is  0.9002328900909022
Epoch  210 Loss  0.19255506992340088
Training accuracy is  0.9001577642551274
Epoch  220 Loss  0.19165007770061493
Training accuracy is  0.9001577642551274
Epoch  230 Loss  0.19062170386314392
Training accuracy is  0.8997070092404778
Epoch  240 Loss  0.20570823550224304
Training accuracy is  0.9247990383893021
Epoch  250 Loss  0.19298814237117767
Training accuracy is  0.900533393434002
Epoch  260 Loss  0.19126565754413605
Training accuracy is  0.8997070092404778
Epoch  270 Loss  0.1901336908340454
Training accuracy is  0.8996318834047029
Epoch  280 Loss  0.19053508341312408
Training accuracy is  0.9001577642551274
Epoch  290 Loss  0.20512714982032776
Training accuracy is  0.9008338967771017
Epoch  300 Loss  0.19254550337791443
Training accuracy is  0.900458267598227
Epoch  310 Loss  0.19068215787410736
Training accuracy is  0.9002328900909022
Epoch  320 Loss  0.1894443780183792
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Training accuracy is  0.8997821350762527
Epoch  330 Loss  0.20212049782276154
Training accuracy is  0.8609420779806175
Epoch  340 Loss  0.19299498200416565
Training accuracy is  0.9006085192697769
Epoch  350 Loss  0.18963225185871124
Training accuracy is  0.8994065058973781
Epoch  360 Loss  0.18941625952720642
Training accuracy is  0.8999323867478025
Epoch  370 Loss  0.1890898048877716
Training accuracy is  0.8997821350762527
Epoch  380 Loss  0.19326473772525787
Training accuracy is  0.9020359101495005
Epoch  390 Loss  0.19154676795005798
Training accuracy is  0.9002328900909022
Epoch  400 Loss  0.1922052502632141
Training accuracy is  0.9003080159266772
Epoch  410 Loss  0.18912899494171143
Training accuracy is  0.899556757568928
Epoch  420 Loss  0.18858087062835693
Training accuracy is  0.8997070092404778
Epoch  430 Loss  0.18846535682678223
Training accuracy is  0.900458267598227
Epoch  440 Loss  0.20271988213062286
Training accuracy is  0.8987303733754038
Epoch  450 Loss  0.196727454662323
Training accuracy is  0.9001577642551274
Epoch  460 Loss  0.18865621089935303
Training accuracy is  0.9007587709413267
Epoch  470 Loss  0.19186626374721527
Training accuracy is  0.899556757568928
Epoch  480 Loss  0.19133570790290833
Training accuracy is  0.900458267598227
Epoch  490 Loss  0.18754521012306213
Training accuracy is  0.9000075125835775
Epoch  500 Loss  0.18770349025726318
Training accuracy is  0.9003080159266772
Epoch  510 Loss  0.19398033618927002
Training accuracy is  0.8990308767185035
Epoch  520 Loss  0.19072124361991882
Training accuracy is  0.9002328900909022
Epoch  530 Loss  0.1872195303440094
Training accuracy is  0.8997821350762527
Epoch  540 Loss  0.18686078488826752
Training accuracy is  0.9000075125835775
Epoch  550 Loss  0.18643993139266968
Training accuracy is  0.9001577642551274
Epoch  560 Loss  0.202600359916687
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Training accuracy is   0.9002328900909022
Epoch   570 Loss   0.22246825695037842
Training accuracy is   0.8994065058973781
Epoch   580 Loss   0.20023304224014282
Training accuracy is   0.8992562542258282
Epoch   590 Loss   0.1932944357395172
Training accuracy is   0.899556757568928
Epoch   600 Loss   0.19044628739356995
Training accuracy is   0.8998572609120277
Epoch   610 Loss   0.18847158551216125
Training accuracy is   0.9001577642551274
Epoch   620 Loss   0.18807902932167053
Training accuracy is   0.9001577642551274
Epoch   630 Loss   0.1874133199453354
Training accuracy is   0.9001577642551274
Epoch   640 Loss   0.18704694509506226
Training accuracy is   0.9001577642551274
Epoch   650 Loss   0.18663138151168823
Training accuracy is   0.9001577642551274
Epoch   660 Loss   0.18623536825180054
Training accuracy is   0.9002328900909022
Epoch   670 Loss   0.18833215534687042
Training accuracy is   0.9011344001202013
Epoch   680 Loss   0.186615452170372
Training accuracy is   0.8792727819096987
Epoch   690 Loss   0.1994950920343399
Training accuracy is   0.9001577642551274
Epoch   700 Loss   0.18979021906852722
Training accuracy is   0.9006085192697769
Epoch   710 Loss   0.18939362466335297
Training accuracy is   0.9001577642551274
Epoch   720 Loss   0.1875966340303421
Training accuracy is   0.9003080159266772
Epoch   730 Loss   0.1868320256471634
Training accuracy is   0.9001577642551274
Epoch   740 Loss   0.18613632023334503
Training accuracy is   0.9002328900909022
Epoch   750 Loss   0.185605987906456
Training accuracy is   0.9002328900909022
Epoch   760 Loss   0.2062578648328781
Training accuracy is   0.8985801217038539
Epoch   770 Loss   0.1856667697429657
Training accuracy is   0.9000075125835775
Epoch   780 Loss   0.18670015037059784
Training accuracy is   0.8999323867478025
Epoch   790 Loss   0.18539807200431824
Training accuracy is   0.9001577642551274
Epoch   800 Loss   0.18654359877109528
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Training accuracy is  0.9000826384193524
Epoch  810 Loss  0.18584930896759033
Training accuracy is  0.9009841484486515
Epoch  820 Loss  0.185947984457016
Training accuracy is  0.9002328900909022
Epoch  830 Loss  0.18586577475070953
Training accuracy is  0.9001577642551274
Epoch  840 Loss  0.19536368548870087
Training accuracy is  0.899481631733153
Epoch  850 Loss  0.18823936581611633
Training accuracy is  0.9009841484486515
Epoch  860 Loss  0.18631789088249207
Training accuracy is  0.9000075125835775
Epoch  870 Loss  0.18942132592201233
Training accuracy is  0.9000826384193524
Epoch  880 Loss  0.1893535852432251
Training accuracy is  0.9010592742844264
Epoch  890 Loss  0.18820078670978546
Training accuracy is  0.9009841484486515
Epoch  900 Loss  0.19211016595363617
Training accuracy is  0.9075200961610698
Epoch  910 Loss  0.18378768861293793
Training accuracy is  0.9002328900909022
Epoch  920 Loss  0.1937229484319687
Training accuracy is  0.8996318834047029
Epoch  930 Loss  0.18436557054519653
Training accuracy is  0.9009090226128765
Epoch  940 Loss  0.1937178373336792
Training accuracy is  0.9011344001202013
Epoch  950 Loss  0.18759742379188538
Training accuracy is  0.9000075125835775
Epoch  960 Loss  0.18666045367717743
Training accuracy is  0.9001577642551274
Epoch  970 Loss  0.18780533969402313
Training accuracy is  0.8997821350762527
Epoch  980 Loss  0.18499977886676788
Training accuracy is  0.9009841484486515
Epoch  990 Loss  0.18644468486309052
Training accuracy is  0.9001577642551274
Epoch  1000 Loss  0.18422938883304596
Training accuracy is  0.9001577642551274
Epoch  1010 Loss  0.18287134170532227
Training accuracy is  0.9009090226128765
Epoch  1020 Loss  0.18695925176143646
Training accuracy is  0.9001577642551274
Epoch  1030 Loss  0.18514692783355713
Training accuracy is  0.9009090226128765
Epoch  1040 Loss  0.21385230123996735
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Training accuracy is  0.854631507775524
Epoch  1050 Loss  0.18799921870231628
Training accuracy is  0.9001577642551274
Epoch  1060 Loss  0.1826520413160324
Training accuracy is  0.9002328900909022
Epoch  1070 Loss  0.1894940584897995
Training accuracy is  0.8999323867478025
Epoch  1080 Loss  0.18300171196460724
Training accuracy is  0.900458267598227
Epoch  1090 Loss  0.19433483481407166
Training accuracy is  0.9665690030801593
Epoch  1100 Loss  0.18281549215316772
Training accuracy is  0.9002328900909022
Epoch  1110 Loss  0.1850775182247162
Training accuracy is  0.9002328900909022
Epoch  1120 Loss  0.19603629410266876
Training accuracy is  0.8997070092404778
Epoch  1130 Loss  0.18649311363697052
Training accuracy is  0.9013597776275261
Epoch  1140 Loss  0.18424618244171143
Training accuracy is  0.9009841484486515
Epoch  1150 Loss  0.1859019547700882
Training accuracy is  0.9009090226128765
Epoch  1160 Loss  0.18385416269302368
Training accuracy is  0.9003080159266772
Epoch  1170 Loss  0.18930844962596893
Training accuracy is  0.8998572609120277
Epoch  1180 Loss  0.18532730638980865
Training accuracy is  0.9025617909999248
Epoch  1190 Loss  0.18364229798316956
Training accuracy is  0.9001577642551274
Epoch  1200 Loss  0.18847288191318512
Training accuracy is  0.9001577642551274
Epoch  1210 Loss  0.18360352516174316
Training accuracy is  0.9002328900909022
Epoch  1220 Loss  0.18919534981250763
Training accuracy is  0.9002328900909022
Epoch  1230 Loss  0.18759478628635406
Training accuracy is  0.9077454736683945
Epoch  1240 Loss  0.18528129160404205
Training accuracy is  0.9010592742844264
Epoch  1250 Loss  0.19517634809017181
Training accuracy is  0.9679212681241078
Epoch  1260 Loss  0.1809530407190323
Training accuracy is  0.900458267598227
Epoch  1270 Loss  0.1916714608669281
Training accuracy is  0.9000826384193524
Epoch  1280 Loss  0.18056660890579224
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Training accuracy is   0.9009090226128765
Epoch   1290 Loss   0.19142970442771912
Training accuracy is   0.9010592742844264
Epoch   1300 Loss   0.1831323802471161
Training accuracy is   0.9006085192697769
Epoch   1310 Loss   0.19086137413978577
Training accuracy is   0.9266020584479002
Epoch   1320 Loss   0.1849316954612732
Training accuracy is   0.9013597776275261
Epoch   1330 Loss   0.19224685430526733
Training accuracy is   0.9349410262189167
Epoch   1340 Loss   0.18015557527542114
Training accuracy is   0.9009090226128765
Epoch   1350 Loss   0.1909036636352539
Training accuracy is   0.8930208098565097
Epoch   1360 Loss   0.23412127792835236
Training accuracy is   0.900533393434002
Epoch   1370 Loss   0.1910994052886963
Training accuracy is   0.8996318834047029
Epoch   1380 Loss   0.18827222287654877
Training accuracy is   0.9018105326421757
Epoch   1390 Loss   0.18620669841766357
Training accuracy is   0.9002328900909022
Epoch   1400 Loss   0.18468347191810608
Training accuracy is   0.900533393434002
Epoch   1410 Loss   0.18393687903881073
Training accuracy is   0.9003831417624522
Epoch   1420 Loss   0.18328741192817688
Training accuracy is   0.900458267598227
Epoch   1430 Loss   0.18260139226913452
Training accuracy is   0.9006085192697769
Epoch   1440 Loss   0.18193185329437256
Training accuracy is   0.900533393434002
Epoch   1450 Loss   0.18124233186244965
Training accuracy is   0.9006085192697769
Epoch   1460 Loss   0.18055784702301025
Training accuracy is   0.9006836451055518
Epoch   1470 Loss   0.229680135846138
Training accuracy is   0.8985049958680791
Epoch   1480 Loss   0.21954216063022614
Training accuracy is   0.802869806926602
Epoch   1490 Loss   0.21020668745040894
Training accuracy is   0.8981293666892044
Epoch   1500 Loss   0.19193889200687408
Training accuracy is   0.9047404402373976
Epoch   1510 Loss   0.19110389053821564
Training accuracy is   0.8992562542258282
Epoch   1520 Loss   0.18958446383476257
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Training accuracy is  0.899556757568928
Epoch  1530 Loss  0.1886395961046219
Training accuracy is  0.8997821350762527
Epoch  1540 Loss  0.1882443130016327
Training accuracy is  0.9000826384193524
Epoch  1550 Loss  0.18773071467876434
Training accuracy is  0.9000826384193524
Epoch  1560 Loss  0.18728716671466827
Training accuracy is  0.9000826384193524
Epoch  1570 Loss  0.18687355518341064
Training accuracy is  0.9000826384193524
Epoch  1580 Loss  0.18647782504558563
Training accuracy is  0.9001577642551274
Epoch  1590 Loss  0.18612991273403168
Training accuracy is  0.9002328900909022
Epoch  1600 Loss  0.18583886325359344
Training accuracy is  0.900458267598227
Epoch  1610 Loss  0.18544282019138336
Training accuracy is  0.9003080159266772
Epoch  1620 Loss  0.18505875766277313
Training accuracy is  0.900458267598227
Epoch  1630 Loss  0.18472623825073242
Training accuracy is  0.900458267598227
Epoch  1640 Loss  0.18433980643749237
Training accuracy is  0.900458267598227
Epoch  1650 Loss  0.18418490886688232
Training accuracy is  0.900533393434002
Epoch  1660 Loss  0.18387623131275177
Training accuracy is  0.900458267598227
Epoch  1670 Loss  0.18361033499240875
Training accuracy is  0.9007587709413267
Epoch  1680 Loss  0.1849967986345291
Training accuracy is  0.9009841484486515
Epoch  1690 Loss  0.18371674418449402
Training accuracy is  0.9001577642551274
Epoch  1700 Loss  0.1831064075231552
Training accuracy is  0.9006836451055518
Epoch  1710 Loss  0.18222594261169434
Training accuracy is  0.900533393434002
Epoch  1720 Loss  0.19079402089118958
Training accuracy is  0.9625122079483134
Epoch  1730 Loss  0.18683533370494843
Training accuracy is  0.9002328900909022
Epoch  1740 Loss  0.18361613154411316
Training accuracy is  0.9003831417624522
Epoch  1750 Loss  0.18186959624290466
Training accuracy is  0.900458267598227
Epoch  1760 Loss  0.18116256594657898
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11

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Training accuracy is  0.900533393434002
Epoch  1770 Loss  0.20570330321788788
Training accuracy is  0.8997070092404778
Epoch  1780 Loss  0.18212327361106873
Training accuracy is  0.9006085192697769
Epoch  1790 Loss  0.18320399522781372
Training accuracy is  0.9009090226128765
Epoch  1800 Loss  0.18312779068946838
Training accuracy is  0.9002328900909022
Epoch  1810 Loss  0.18545286357402802
Training accuracy is  0.9002328900909022
Epoch  1820 Loss  0.18545717000961304
Training accuracy is  0.901510029299076
Epoch  1830 Loss  0.18402419984340668
Training accuracy is  0.9010592742844264
Epoch  1840 Loss  0.19131958484649658
Training accuracy is  0.9172864548118098
Epoch  1850 Loss  0.17999058961868286
Training accuracy is  0.9008338967771017
Epoch  1860 Loss  0.20244605839252472
Training accuracy is  0.899556757568928
Epoch  1870 Loss  0.19008301198482513
Training accuracy is  0.9038389302080986
Epoch  1880 Loss  0.1811356544494629
Training accuracy is  0.900458267598227
Epoch  1890 Loss  0.19659002125263214
Training accuracy is  0.9086469836976936
Epoch  1900 Loss  0.18737973272800446
Training accuracy is  0.9011344001202013
Epoch  1910 Loss  0.18045945465564728
Training accuracy is  0.9009090226128765
Epoch  1920 Loss  0.1798037886619568
Training accuracy is  0.9009090226128765
Epoch  1930 Loss  0.20447716116905212
Training accuracy is  0.9429043648110585
Epoch  1940 Loss  0.18439951539039612
Training accuracy is  0.9003831417624522
Epoch  1950 Loss  0.18462926149368286
Training accuracy is  0.9022612876568252
Epoch  1960 Loss  0.18759781122207642
Training accuracy is  0.9500413192096762
Epoch  1970 Loss  0.17946039140224457
Training accuracy is  0.9009090226128765
Epoch  1980 Loss  0.19049221277236938
Training accuracy is  0.9000826384193524
Epoch  1990 Loss  0.17902198433876038
Training accuracy is  0.9009841484486515
Epoch  2000 Loss  0.18713007867336273
```

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Training accuracy is   0.9012846517917512
Epoch   2010 Loss   0.1819436401128769
Training accuracy is   0.8726617083615055
Epoch   2020 Loss   0.18149586021900177
Training accuracy is   0.9009841484486515
Epoch   2030 Loss   0.18080998957157135
Training accuracy is   0.9009090226128765
Epoch   2040 Loss   0.1795567125082016
Training accuracy is   0.900533393434002
Epoch   2050 Loss   0.192521870136261
Training accuracy is   0.9000826384193524
Epoch   2060 Loss   0.1933119148015976
Training accuracy is   0.8938471940500338
Epoch   2070 Loss   0.18716304004192352
Training accuracy is   0.9013597776275261
Epoch   2080 Loss   0.1800653636455536
Training accuracy is   0.9006836451055518
Epoch   2090 Loss   0.1824742704629898
Training accuracy is   0.9048906919089474
Epoch   2100 Loss   0.1900578886270523
Training accuracy is   0.9230711441664788
Epoch   2110 Loss   0.19217482209205627
Training accuracy is   0.9018856584779505
Epoch   2120 Loss   0.18390464782714844
Training accuracy is   0.9002328900909022
Epoch   2130 Loss   0.1806781142950058
Training accuracy is   0.900533393434002
Epoch   2140 Loss   0.17884387075901031
Training accuracy is   0.9026369168356998
Epoch   2150 Loss   0.18732957541942596
Training accuracy is   0.9149575539027872
Epoch   2160 Loss   0.18313367664813995
Training accuracy is   0.9002328900909022
Epoch   2170 Loss   0.18008078634738922
Training accuracy is   0.9007587709413267
Epoch   2180 Loss   0.17853040993213654
Training accuracy is   0.9008338967771017
Epoch   2190 Loss   0.1852964460849762
Training accuracy is   0.9002328900909022
Epoch   2200 Loss   0.19651387631893158
Training accuracy is   0.8962512207948313
Epoch   2210 Loss   0.1829298883676529
Training accuracy is   0.9010592742844264
Epoch   2220 Loss   0.1786121279001236
Training accuracy is   0.9008338967771017
Epoch   2230 Loss   0.1839727908372879
Training accuracy is   0.9251746675681767
Epoch   2240 Loss   0.18361368775367737
```

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Training accuracy is  0.9010592742844264
Epoch  2250 Loss  0.19754545390605927
Training accuracy is  0.9184884681842086
Epoch  2260 Loss  0.1812305897474289
Training accuracy is  0.9006836451055518
Epoch  2270 Loss  0.17849880456924438
Training accuracy is  0.9006836451055518
Epoch  2280 Loss  0.17856557667255402
Training accuracy is  0.901434903463301
Epoch  2290 Loss  0.18703238666057587
Training accuracy is  0.9215686274509803
Epoch  2300 Loss  0.19052255153656006
Training accuracy is  0.9002328900909022
Epoch  2310 Loss  0.17828616499900818
Training accuracy is  0.9009090226128765
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Training accuracy is  0.914056043873488
Epoch  2340 Loss  0.17698934674263
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Epoch  2350 Loss  0.20464594662189484
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Training accuracy is  0.9009090226128765
Epoch  2370 Loss  0.1949818730354309
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Epoch  2380 Loss  0.1770307868719101
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Epoch  2440 Loss  0.17790593206882477
Training accuracy is  0.9009841484486515
Epoch  2450 Loss  0.18622416257858276
Training accuracy is  0.9002328900909022
Epoch  2460 Loss  0.18193590641021729
Training accuracy is  0.900458267598227
Epoch  2470 Loss  0.17892304062843323
Training accuracy is  0.9006085192697769
Epoch  2480 Loss  0.18800528347492218
```

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Training accuracy is  0.9001577642551274
Epoch  2490 Loss  0.17707303166389465
Training accuracy is  0.9008338967771017
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Epoch  2720 Loss  0.18160444498062134
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Training accuracy is  0.900533393434002
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Epoch  2950 Loss  0.1774124801158905
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Epoch  2960 Loss  0.17871403694152832
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Training accuracy is  0.9006836451055518
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Epoch  3190 Loss  0.17964132130146027
Training accuracy is  0.9637893471564871
Epoch  3200 Loss  0.18432822823524475
```

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Training accuracy is  0.9829464352790925
Epoch  3210 Loss  0.18042254447937012
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Training accuracy is  0.9664938772443843
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Training accuracy is  0.9831718127864173
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Training accuracy is  0.9829464352790925
Epoch  3260 Loss  0.17712557315826416
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Training accuracy is  0.9844489519945909
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Epoch  3420 Loss  0.1765812784433365
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Training accuracy is  0.9769363684170986
Epoch  3440 Loss  0.18128249049186707
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Training accuracy is  0.9844489519945909
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Epoch  3510 Loss  0.17622791230678558
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Epoch  3580 Loss  0.17942434549331665
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Epoch  3680 Loss  0.18287807703018188
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Epoch   3690 Loss   0.17894716560840607
Training accuracy is   0.9822703027571181
Epoch   3700 Loss   0.17432901263237
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Training accuracy is   0.9707760498835549
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Epoch   3810 Loss   0.18129485845565796
Training accuracy is   0.9847494553376906
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Epoch   3910 Loss   0.17909760773181915
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Epoch   3920 Loss   0.1743263304233551
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Training accuracy is   0.9839230711441664
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Training accuracy is   0.9839981969799414
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Training accuracy is   0.9870783562467133
Epoch   4150 Loss   0.17951934039592743
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Epoch   4160 Loss   0.17604143917560577
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Training accuracy is  0.9850499586807904
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Epoch  4400 Loss  0.17294275760650635
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Epoch  7040 Loss  0.15601398050785065
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Epoch   9350 Loss   0.15851758420467377
Training accuracy is   0.9009841484486515
Epoch   9360 Loss   0.15794183313846588
Training accuracy is   0.9009841484486515
Epoch   9370 Loss   0.159287229180336
Training accuracy is   0.9009841484486515
Epoch   9380 Loss   0.16132187843322754
Training accuracy is   0.9009841484486515
Epoch   9390 Loss   0.1581287533044815
Training accuracy is   0.9009841484486515
Epoch   9400 Loss   0.1582232117652893
Training accuracy is   0.9009841484486515
Epoch   9410 Loss   0.15544256567955017
Training accuracy is   0.9009841484486515
Epoch   9420 Loss   0.1575905978679657
Training accuracy is   0.9009841484486515
Epoch   9430 Loss   0.16894163191318512
Training accuracy is   0.9009090226128765
Epoch   9440 Loss   0.16426289081573486
```

```
Training accuracy is  0.9008338967771017
Epoch  9450 Loss  0.2574108839035034
Training accuracy is  0.9007587709413267
Epoch  9460 Loss  0.2117592990398407
Training accuracy is  0.9002328900909022
Epoch  9470 Loss  0.24832774698734283
Training accuracy is  0.9009841484486515
Epoch  9480 Loss  0.1554996818304062
Training accuracy is  0.9051160694162722
Epoch  9490 Loss  0.1619713008403778
Training accuracy is  0.9333633836676433
Epoch  9500 Loss  0.15679240226745605
Training accuracy is  0.9081211028472692
Epoch  9510 Loss  0.15438345074653625
Training accuracy is  0.9016602809706258
Epoch  9520 Loss  0.15345057845115662
Training accuracy is  0.9086469836976936
Epoch  9530 Loss  0.15265844762325287
Training accuracy is  0.912177897979115
Epoch  9540 Loss  0.1514662802219391
Training accuracy is  0.9149575539027872
Epoch  9550 Loss  0.15038062632083893
Training accuracy is  0.9117271429644654
Epoch  9560 Loss  0.14931711554527283
Training accuracy is  0.9150326797385621
Epoch  9570 Loss  0.14811404049396515
Training accuracy is  0.9175118323191346
Epoch  9580 Loss  0.14732681214809418
Training accuracy is  0.919014349034633
Epoch  9590 Loss  0.14661027491092682
Training accuracy is  0.9214183757794305
Epoch  9600 Loss  0.14589251577854156
Training accuracy is  0.9235970250169033
Epoch  9610 Loss  0.14821141958236694
Training accuracy is  0.9757343550446999
Epoch  9620 Loss  0.1596454679965973
Training accuracy is  0.9585305386522425
Epoch  9630 Loss  0.17241565883159637
Training accuracy is  0.9397490797085117
Epoch  9640 Loss  0.16655726730823517
Training accuracy is  0.9501915708812261
Epoch  9650 Loss  0.17093977332115173
Training accuracy is  0.9579295319660431
Epoch  9660 Loss  0.1676061451435089
Training accuracy is  0.9613853204116896
Epoch  9670 Loss  0.168303444981575
Training accuracy is  0.9646157313500112
Epoch  9680 Loss  0.16608791053295135
```

```
Training accuracy is   0.9676958906167831
Epoch   9690 Loss   0.16552676260471344
Training accuracy is   0.9682217714672076
Epoch   9700 Loss   0.1652207374572754
Training accuracy is   0.9690481556607318
Epoch   9710 Loss   0.16572241485118866
Training accuracy is   0.9671700097663587
Epoch   9720 Loss   0.16548259556293488
Training accuracy is   0.9671700097663587
Epoch   9730 Loss   0.1674305647611618
Training accuracy is   0.9614604462474645
Epoch   9740 Loss   0.1658194214105606
Training accuracy is   0.965892870558185
Epoch   9750 Loss   0.16491928696632385
Training accuracy is   0.9692735331680565
Epoch   9760 Loss   0.16385012865066528
Training accuracy is   0.9719780632559537
Epoch   9770 Loss   0.16308489441871643
Training accuracy is   0.9743069641649763
Epoch   9780 Loss   0.16336597502231598
Training accuracy is   0.9738562091503268
Epoch   9790 Loss   0.16355904936790466
Training accuracy is   0.9735557058072271
Epoch   9800 Loss   0.16405265033245087
Training accuracy is   0.9710014273908797
Epoch   9810 Loss   0.1635570526123047
Training accuracy is   0.9710014273908797
Epoch   9820 Loss   0.1634981781244278
Training accuracy is   0.9703252948689054
Epoch   9830 Loss   0.16275979578495026
Training accuracy is   0.9728044474494779
Epoch   9840 Loss   0.16258762776851654
Training accuracy is   0.9735557058072271
Epoch   9850 Loss   0.16274772584438324
Training accuracy is   0.9733303282999023
Epoch   9860 Loss   0.16250351071357727
Training accuracy is   0.9732552024641274
Epoch   9870 Loss   0.16241022944450378
Training accuracy is   0.973705957478777
Epoch   9880 Loss   0.16191312670707703
Training accuracy is   0.9752084741942754
Epoch   9890 Loss   0.1617816835641861
Training accuracy is   0.9725039441063782
Epoch   9900 Loss   0.16188977658748627
Training accuracy is   0.9734805799714522
Epoch   9910 Loss   0.16778770089149475
Training accuracy is   0.9430546164826084
Epoch   9920 Loss   0.16473862528800964
```

```
Training accuracy is  0.9569528961009691
Epoch  9930 Loss  0.16445353627204895
Training accuracy is  0.9617609495905642
Epoch  9940 Loss  0.1655457466840744
Training accuracy is  0.9566523927578694
Epoch  9950 Loss  0.16705583035945892
Training accuracy is  0.924874164225077
Epoch  9960 Loss  0.1570350080728531
Training accuracy is  0.9009841484486515
Epoch  9970 Loss  0.145448237657547
Training accuracy is  0.9011344001202013
Epoch  9980 Loss  0.1556510627269745
Training accuracy is  0.9398993313800617
Epoch  9990 Loss  0.15438410639762878
Training accuracy is  0.9066185861317707
```

Epoch 5240 Loss 0.17049048840999603 Training accuracy is 0.9900082638419352

[5]:
```python
plt.scatter(X[:, 0], X[:, 1], c=pred, cmap=plt.cm.Spectral, s = 1)
plot_decision_boundary(net, X, y, 'P2_Q2_A.pdf')
```

```
C:\Users\aradh\AppData\Local\Temp\ipykernel_53704\2298959118.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]:
```python
plot_decision_boundary(net, X, y, 'P2_Q2_A')
```

```
C:\Users\aradh\AppData\Local\Temp\ipykernel_53704\2298959118.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)
```

[ ]: