P2_Q1_B

November 15, 2022

[16]:

```
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

class Net(nn.Module):

    def __init__(self):
        super(Net, self).__init__()
        self.fc1 = nn.Linear(2, 4)
        self.fc2 = nn.Linear(4, 4)
        self.fc3 = nn.Linear(4, 4)
        #self.fc4 = nn.Linear(4, 4)
        self.fc5 = nn.Linear(4, 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 = self.fc5(x)
        return F.log_softmax(x)
        #return F.softmax(x)
```

[17]:

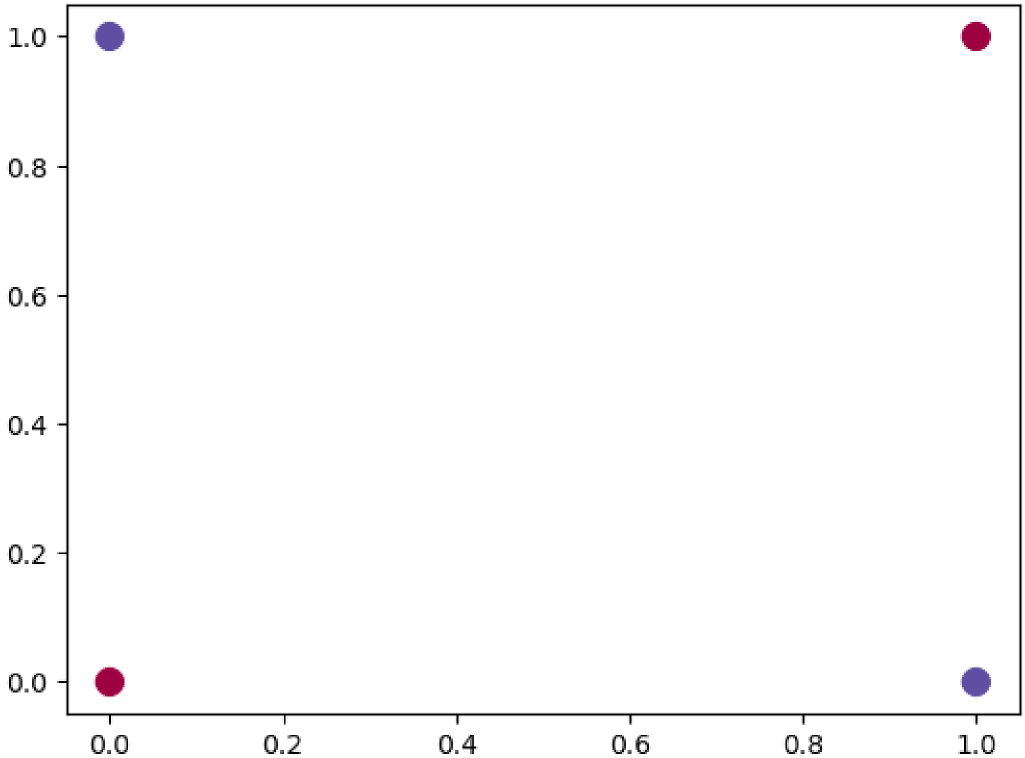
```
def plot_data(X, y, filename):
    plt.scatter(X[:, 0], X[:, 1], c=y, cmap=plt.cm.Spectral, s = 1)
    plt.savefig(filename)
    plt.close()

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 = -0.5, 1.5
    y_min, y_max = -0.5, 1.5
```

```
    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("XOR.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 = 100)
```

[17]: <matplotlib.collections.PathCollection at 0x1a1e6dbf370>



[18]:
```
#%% 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.Adam(net.parameters(), lr=learning_rate)


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

#nepochs = 600
nepochs = 5000
#10000
data, target = X, y


for epoch in range(nepochs):
#    adjust learning rate if desired
#    if epoch % 3000 == 0 and epoch <= 24000:
```

```python
#         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):
```

```
C:\Users\aradh\AppData\Local\Temp\ipykernel_59588\507983196.py:24: 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  0.6971863508224487
Training accuracy is  0.5
Epoch  10 Loss  0.6886703372001648
Training accuracy is  0.75
Epoch  20 Loss  0.6704367399215698
Training accuracy is  0.75
Epoch  30 Loss  0.6011072993278503
Training accuracy is  0.75
Epoch  40 Loss  0.43836694955825806
Training accuracy is  1.0
Epoch  50 Loss  0.25278791785240173
Training accuracy is  1.0
Epoch  60 Loss  0.10162724554538727
Training accuracy is  1.0
Epoch  70 Loss  0.02773212268948555
Training accuracy is  1.0
```

```
Epoch  80 Loss  0.008036627434194088
Training accuracy is  1.0
Epoch  90 Loss  0.0033594490960240364
Training accuracy is  1.0
Epoch  100 Loss  0.0019726341124624014
Training accuracy is  1.0
Epoch  110 Loss  0.001395600731484592
Training accuracy is  1.0
Epoch  120 Loss  0.0010881959460675716
Training accuracy is  1.0
Epoch  130 Loss  0.0008862526738084853
Training accuracy is  1.0
Epoch  140 Loss  0.0007425008807331324
Training accuracy is  1.0
Epoch  150 Loss  0.0006310101598501205
Training accuracy is  1.0
Epoch  160 Loss  0.0005419619847089052
Training accuracy is  1.0
Epoch  170 Loss  0.00046937662409618497
Training accuracy is  1.0
Epoch  180 Loss  0.0004091769515071064
Training accuracy is  1.0
Epoch  190 Loss  0.0003589825064409524
Training accuracy is  1.0
Epoch  200 Loss  0.0003167990653309971
Training accuracy is  1.0
Epoch  210 Loss  0.00028116791509091854
Training accuracy is  1.0
Epoch  220 Loss  0.0002507790341041982
Training accuracy is  1.0
Epoch  230 Loss  0.00022488803369924426
Training accuracy is  1.0
Epoch  240 Loss  0.00020254192349966615
Training accuracy is  1.0
Epoch  250 Loss  0.00018323439871892333
Training accuracy is  1.0
Epoch  260 Loss  0.00016639954992569983
Training accuracy is  1.0
Epoch  270 Loss  0.0001517395576229319
Training accuracy is  1.0
Epoch  280 Loss  0.00013883737847208977
Training accuracy is  1.0
Epoch  290 Loss  0.00012748448352795094
Training accuracy is  1.0
Epoch  300 Loss  0.00011741276102839038
Training accuracy is  1.0
Epoch  310 Loss  0.0001085328622139059
Training accuracy is  1.0
```

```
Epoch  320 Loss  0.00010051704884972423
Training accuracy is  1.0
Epoch  330 Loss  9.342491102870554e-05
```

[19]:

```
plt.scatter(X[:, 0], X[:, 1], c=pred, cmap=plt.cm.Spectral, s = 1)
plot_decision_boundary(net, X, y, 'P2_Q1_B.pdf')
```

```
C:\Users\aradh\AppData\Local\Temp\ipykernel_59588\507983196.py:24: 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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