Week 6 Programming Assignment

Thursday, February 16, 2023 9:09 AM

#1 Binary Perception

(a)

part a - functions for classification

```
In [2]: def classify(w,b,x):
            dot_prod = sum([w[i]*x[i] for i in range(len[x])])
            label = 1 if dot_product + b >= 0 else -1
            return label
```

```
In [3]: def perceptron(data,labels):
            perm = np.random.permutation(len(labels))
            x = data[perm]
            y = labels[perm]

            w = np.zeros(x.shape[1])
            b = 0

            for i in range(x.shape[0]):
                if y[i] *(np.dot(w,x[i]) + b) <= 0:
                    w = w + y[i]*x[i]
                    b = b + y[i]

            return w,b
```

(b)

part b - loading and recoding the iris dataset

importing iris dataset

```
[4]: from sklearn import datasets
     iris = datasets.load_iris()
     x = iris.data
     y = iris.target
```

select features 1 &3, recode 0 as -1 and drop all instances of 2

```
[5]: x_subset = np.column_stack((x[:100,1], x[:100,3]))
     y_recode = np.where(y == 0, -1, y)
     y_recode = y_recode[y_recode != 2]
```

(c)

part c - running the perceptron and plotting the results

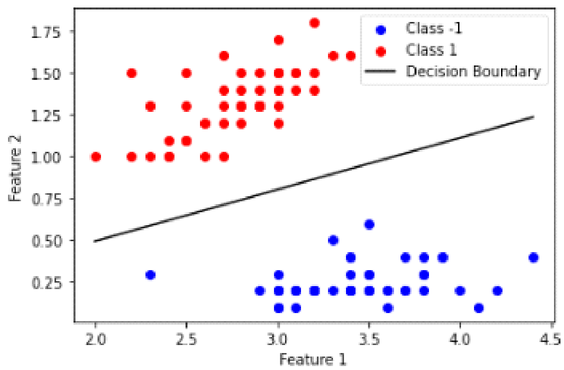
running the perceptron

In [6]:
```
w,b = perceptron(x_subset, y_recode)
w,b
```

Out[6]:
```
(array([-2.5,  8.1]), 1)
```

plotting the data and decision boundaries

In [7]:
```
import matplotlib.pyplot as plt
%matplotlib inline

# Scatter plot the data points
plt.scatter(x_subset[y_recode==-1,0], x_subset[y_recode==-1,1], color='b', label='Class -1')
plt.scatter(x_subset[y_recode==1,0], x_subset[y_recode==1,1], color='r', label='Class 1')

# Plot the decision boundary
x_axis = np.linspace(np.min(x_subset[:,0]), np.max(x_subset[:,0]), 100)
y_axis = -(b + w[0]*x_axis) / w[1]
plt.plot(x_axis, y_axis, color='k', label='Decision Boundary')

# Set plot labels and legend
plt.xlabel('Feature 1')
plt.ylabel('Feature 2')
plt.legend()

# Show the plot
plt.show()
```



(d)

part d - update counter

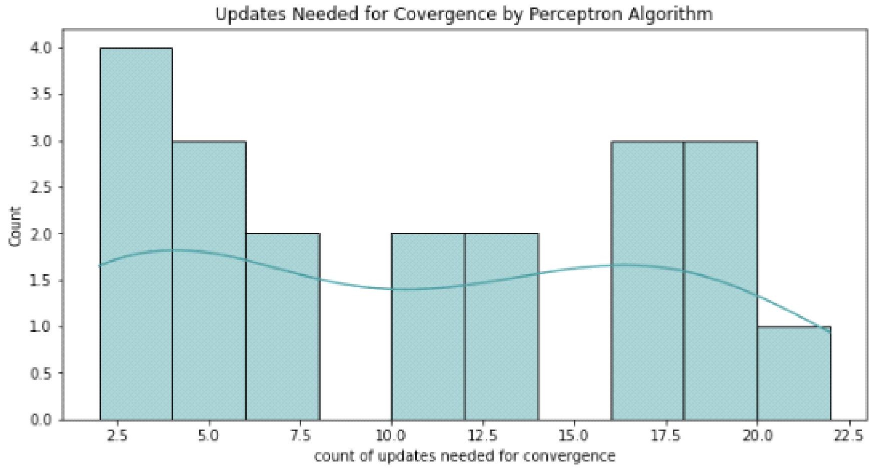
In [8]:
```
def perceptron_updates(data,labels):
    iterations = 20
    updates = []

    for n in range(iterations):
        perm = np.random.permutation(len(labels))
        x = data[perm]
        y = labels[perm]

        w = np.zeros(x.shape[1])
        b = 0
        counter = 0

        for i in range(x.shape[0]):
            if y[i] *(np.dot(w,x[i]) + b) <= 0:
                w = w + y[i]*x[i]
                b = b + y[i]
                counter += 1

        updates.append(counter)

    return updates
```

In [9]:
```
updates = perceptron_updates(x_subset, y_recode)
updates
```

Out[9]:
```
[22, 2, 19, 2, 17, 13, 11, 2, 2, 19, 4, 6, 11, 6, 17, 13, 18, 4, 17, 4]
```

In [10]:
```
import seaborn as sns
plt.figure(figsize = (10,5))
ax = sns.histplot(updates, color='#4c9ca1', bins=10, kde=True)
ax.set(xlabel="count of updates needed for convergence", title = "Updates Needed for Covergence by Perceptron Algorithm")
```

Out[10]:
```
[Text(0.5, 0, 'count of updates needed for convergence'),
 Text(0.5, 1.0, 'Updates Needed for Covergence by Perceptron Algorithm')]
```



#2 SVM

(a)

(a) Is the data linearly separable?

Yes, based on the plot from question 1c the data appears to be linearly separable.

(b)

(b) support vector machine classifier

select features 0,2 from the iris data set and labels 1,2

In [11]:
```
x_sub = np.column_stack((x[50:,0], x[50:,2]))
y_sub = y[y != 0]
```

fit SVM classifier to the data

In [12]:
```
from sklearn.svm import SVC
from sklearn.model_selection import train_test_split
```

In [13]:
```
x_train, x_test, y_train, y_test = train_test_split(x_sub, y_sub, test_size = 0.2, random_state = 0)
```

In [14]:
```
C_values = [0.1, 0.5, 1, 5, 10, 20, 50, 100, 1000, 100000]
training_errors= []
num_supp_vectors = []

for C in C_values:
    clf = SVC(kernel='linear', C=C)
    clf.fit(x_train, y_train)
    training_error = round((1 - clf.score(x_train, y_train)),4)
    n_supp_vect = sum(clf.n_support_)
    training_errors.append(training_error)
    num_supp_vectors.append(n_supp_vect)
```

In [15]:
```
d = {'C':C_values, 'Training Error':training_errors, 'Number of Support Vectors':num_supp_vectors}
df = pd.DataFrame(data=d).set_index('C')
df
```

Out[15]:

C	Training Error	Number of Support Vectors
0.1	0.0625	46
0.5	0.0375	31
1.0	0.0500	24
5.0	0.0500	15
10.0	0.0250	13
20.0	0.0375	10
50.0	0.0375	8
100.0	0.0375	8
1000.0	0.0375	7
100000.0	0.0375	6

(c)

(c) best value of C

In [16]:
```
y_pred = clf.predict(x_test)
test_error = round((1 - clf.score(x_test, y_test)), 4)

d2 = {'C':C_values, 'Training Error':training_errors, 'Test Error':test_error, 'Number of Support Vectors':num_supp_vectors}
df2 = pd.DataFrame(data=d2).set_index('C')
df2
```

Out[16]:

C	Training Error	Test Error	Number of Support Vectors
0.1	0.0625	0.1	46
0.5	0.0375	0.1	31
1.0	0.0500	0.1	24
5.0	0.0500	0.1	15
10.0	0.0250	0.1	13
20.0	0.0375	0.1	10
50.0	0.0375	0.1	8
100.0	0.0375	0.1	8
1000.0	0.0375	0.1	7
100000.0	0.0375	0.1	6

Based on the table above, the value of C that minimizes training error without compromising test error seems to be 10.

In [17]:
```
clf10 = SVC(kernel='linear', C=10)
clf10.fit(x_train, y_train)
```

Out[17]: SVC(C=10, kernel='linear')

In [26]:
```
sv = np.zeros(80,dtype=bool)
sv[clf10.support_] = True
notsv = np.logical_not(sv)

delta = 0.005
x_min, x_max = 4, 8.5
y_min, y_max = 2, 8
xx, yy = np.meshgrid(np.arange(x_min, x_max, delta), np.arange(y_min, y_max, delta))
Z = clf.decision_function(np.c_[xx.ravel(), yy.ravel()])
for i in range(len(Z)):
    Z[i] = min(Z[i],1.0)
    Z[i] = max(Z[i],-1.0)
    if (Z[i] > 0.0) and (Z[i] < 1.0):
        Z[i] = 0.5
    if (Z[i] < 0.0) and (Z[i] > -1.0):
        Z[i] = -0.5
# Put the result into a color plot
Z = Z.reshape(xx.shape)
plt.pcolormesh(xx, yy, Z, cmap=plt.cm.PRGn, vmin=-2, vmax=2)

# Plot also the training points
plt.plot(x_train[(y_train==1)*notsv,0], x_train[(y_train==1)*notsv,1], 'ro')
plt.plot(x_train[(y_train==1)*sv,0], x_train[(y_train==1)*sv,1], 'ro', markersize=10)
plt.plot(x_train[(y_train==2)*notsv,0], x_train[(y_train==2)*notsv,1], 'k^')
plt.plot(x_train[(y_train==2)*sv,0], x_train[(y_train==2)*sv,1], 'k^', markersize=10)
plt.xlabel('Sepal Length', fontsize=14, color='red')
plt.ylabel('Petal Length', fontsize=14, color='red')

plt.xlim(x_min, x_max)
plt.ylim(y_min, y_max)
plt.show()
```