Homework 2

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```
In [1]: import numpy
         from urllib.request import urlopen
         import scipy.optimize
         import random
         import ast
         from sklearn.decomposition import PCA
         from collections import defaultdict
         import networkx as nx
         import matplotlib.pyplot as plt
         from sklearn.metrics import precision_recall_curve
         from sklearn.utils.fixes import signature
         from math import exp
         from math import log
```

0.0.1 Question 1

```
In [2]: def parseData(fname):
          for l in open(fname):
            yield ast.literal_eval(l)
```

```
In [3]: print("Reading data...")
        data = list(parseData("beer_50000.json"))
        print("done")
```

```
Reading data...
done
```

```
In [4]: def feature(datum):
          feat = [1, datum['review/taste'], datum['review/appearance'], datum['review/aroma'],
           datum['review/palate'], datum['review/overall']]
          return feat

        X = [feature(d) for d in data]
        y = [d['beer/ABV'] >= 6.5 for d in data]
```

```
In [5]: def inner(x,y):
          return sum([x[i]*y[i] for i in range(len(x))])
```

```
def sigmoid(x):
  return 1.0 / (1 + exp(-x))
```

In [6]:

```
##################################################
# Logistic regression by gradient ascent         #
##################################################

# NEGATIVE Log-likelihood
def f(theta, X, y, lam):
  loglikelihood = 0
  for i in range(len(X)):
    logit = inner(X[i], theta)
    loglikelihood -= log(1 + exp(-logit))
    if not y[i]:
      loglikelihood -= logit
  for k in range(len(theta)):
    loglikelihood -= lam * theta[k]*theta[k]
  # for debugging
  # print("ll =" + str(loglikelihood))
  return -loglikelihood

# NEGATIVE Derivative of log-likelihood
def fprime(theta, X, y, lam):
  dl = [0]*len(theta)
  for i in range(len(X)):
    logit = inner(X[i], theta)
    for k in range(len(theta)):
      dl[k] += X[i][k] * (1 - sigmoid(logit))
      if not y[i]:
        dl[k] -= X[i][k]
  for k in range(len(theta)):
    dl[k] -= lam*2*theta[k]
  return numpy.array([-x for x in dl])

ind_list = [i for i in range(len(X))]
random.shuffle(ind_list)
random_X = []
random_y = []

for i in ind_list:
    random_X.append(X[i])
    random_y.append(y[i])

X_train = random_X[:len(random_X)//3]
y_train = random_y[:len(random_y)//3]

X_test = random_X[len(random_X)//3 + 1:2*len(random_X)//3]
```

```
        y_test = random_y[len(random_y)//3 + 1:2*len(random_y)//3]

        X_val = random_X[2*len(random_X)//3:]
        y_val = random_y[2*len(random_y)//3:]
```

```
In [7]: ##################################################
        # Train                                          #
        ##################################################

        def train(lam):
          theta,_,_ = scipy.optimize.fmin_l_bfgs_b(f, [0]*len(X[0]), fprime, pgtol = 10, args =
          return theta
```

```
In [8]: ##################################################
        # Predict                                        #
        ##################################################

        def performance(theta, X_test, y_test):
          scores = [inner(theta,x) for x in X_test]
          predictions = [s > 0 for s in scores]
          correct = [(a==b) for (a,b) in zip(predictions,y_test)]
          acc = sum(correct) * 1.0 / len(correct)
          return predictions, acc, scores
```

```
In [9]: ##################################################
         # Validation pipeline                            #
         ##################################################

         lam = 1.0

         theta = train(lam)
         train_predictions, train_acc, train_scores = performance(theta, X_train, y_train)
         test_predictions, test_acc, test_scores = performance(theta, X_test, y_test)
         val_predictions, val_acc, val_scores = performance(theta, X_val, y_val)
         print("lambda = " + str(lam))
         print("Train:\taccuracy=" + str(train_acc))
         print("Test:\taccuracy=" + str(test_acc))
         print("Validation:\taccuracy=" + str(val_acc))
```

```
lambda = 1.0
Train:        accuracy=0.7214088563542542
Test:        accuracy=0.7146285851434058
Validation:        accuracy=0.7153056938861223
```

0.0.2 Question 2

```
In [16]: tPos = 0
         fPos = 0
         tNeg = 0
         fNeg = 0

         for i in range(len(y_test)):
             if y_test[i] == True and test_predictions[i] == True:
                 tPos += 1
             elif y_test[i] == False and test_predictions[i] == True:
                 fPos += 1
             elif y_test[i] == False and test_predictions[i] == False:
                 tNeg += 1
             else:
                 fNeg += 1

         print("True Positive: " + str(tPos))
         print("False Positive: " + str(fPos))
         print("True Negative: " + str(tNeg))
         print("False Negative: " + str(fNeg))
```

```
True Positive: 9019
False Positive: 3504
True Negative: 2891
False Negative: 1252
```

0.0.3 Question 3

```
In [17]: test_predictions = list(zip(y_test, test_predictions, test_scores))
         test_predictions = sorted(test_predictions, key=lambda x:x[2])
```

```
In [18]: relevantAt100 = sum([1 for v in test_predictions[-100:] if v[0] == True])
         retrievedAt100 = sum([1 for v in test_predictions[-100:] if v[1] == True])
         relRetrievedAt100 = sum([1 for v in test_predictions[-100:]
                                  if v[0] == v[1] and v[0] == True])
         totalRelevant = sum([1 for v in test_predictions if v[0] == True])
         totalRetrieved = sum([1 for v in test_predictions if v[1] == True])
         totalRelRetrieved = sum([1 for v in test_predictions
                                  if v[0] == v[1] and v[0] == True])
```

```
In [19]: precisionAt100 = relRetrievedAt100/retrievedAt100
         recallAt100 = relRetrievedAt100/relevantAt100
         precision = totalRelRetrieved/totalRetrieved
         recall = totalRelRetrieved/totalRelevant
```

```
In [20]: print("Precision@100: " + str(precisionAt100))
         print("Precision: " + str(precision))
         print("Recall@100: " + str(recallAt100))
         print("Recall: " + str(recall))
```

```
Precision@100: 0.92
Precision: 0.7201948414916554
```

```
Recall@100: 1.0
Recall: 0.8781033979164639
```

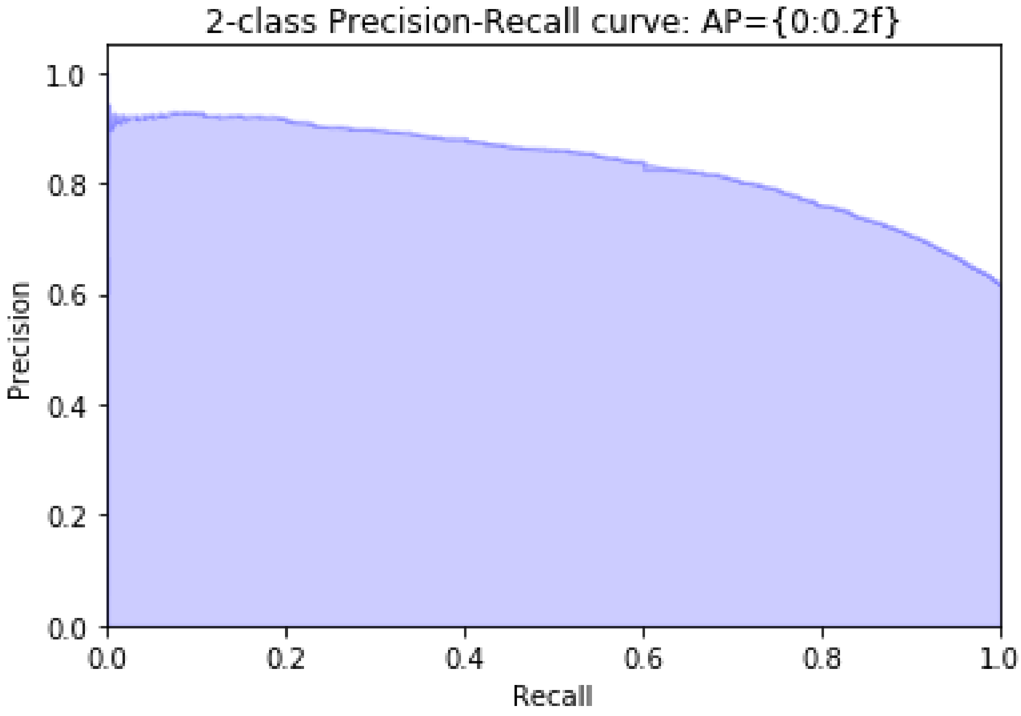
0.0.4 Question 4

```
In [21]: precision, recall, _ = precision_recall_curve(y_test, test_scores)

In [22]: plt.step(recall, precision, color='b', alpha=0.2,
                  where='post')
         plt.fill_between(recall, precision, alpha=0.2, color='b')

         plt.xlabel('Recall')
         plt.ylabel('Precision')
         plt.ylim([0.0, 1.05])
         plt.xlim([0.0, 1.0])
         plt.title('2-class Precision-Recall curve: AP={0:0.2f}')

Out[22]: Text(0.5,1,'2-class Precision-Recall curve: AP={0:0.2f}')
```

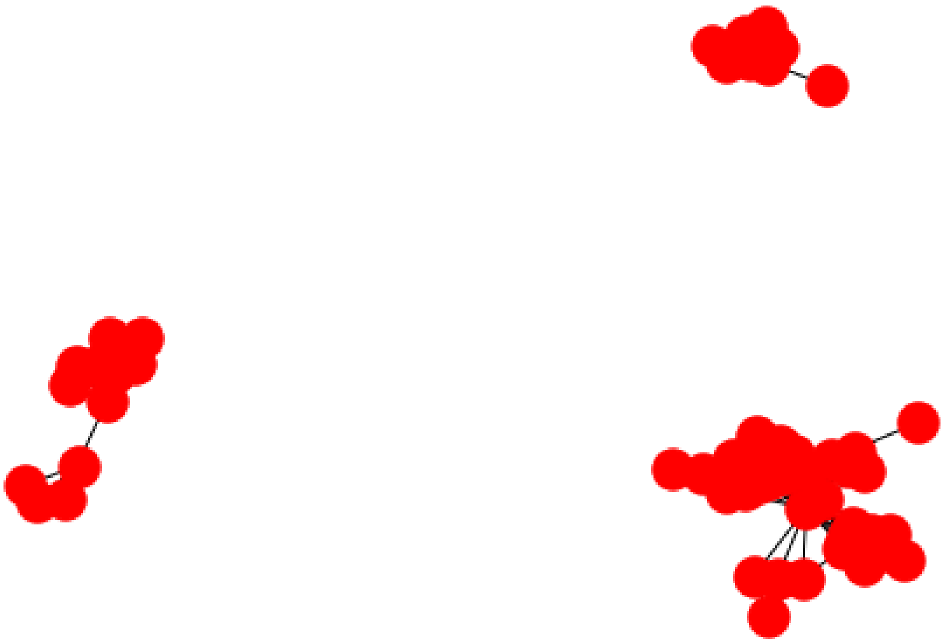


0.0.5 Question 5

```
In [23]: ### Network visualization ###
```

```
edges = set()
nodes = set()
for edge in open("egonet.txt"):
  x,y = edge.split()
  x,y = int(x),int(y)
  edges.add((x,y))
  edges.add((y,x))
  nodes.add(x)
  nodes.add(y)

G = nx.Graph()
for e in edges:
  G.add_edge(e[0],e[1])
nx.draw(G)
plt.show()
plt.clf()
```



```
<Figure size 432x288 with 0 Axes>
```

```
In [24]: connComponents = list(nx.connected_component_subgraphs(G))
```

```
In [25]: for graph in connComponents:
             print(len(graph.nodes))
```

```
40
9
12
```

The graph has 3 connected components and the largest one has 40 nodes

0.0.6 Question 6

```
In [26]: largestCom = connComponents[0]

In [27]: nodes = list(largestCom.nodes)
          edges = list(largestCom.edges)

In [28]: nodes1 = nodes[:len(nodes)//2]
          degrees1 = sum([G.degree(v) for v in nodes1])
          nodes2 = nodes[len(nodes)//2:]
          degrees2 = sum([G.degree(v) for v in nodes2])

In [29]: cuttedEdges = sum([1 for e in edges
if (e[0] in nodes1 and e[1] in nodes2) or (e[0] in nodes2 and e[1] in nodes1)])

In [30]: normCut = cuttedEdges/2*(1/degrees1 + 1/degrees2)

In [31]: print("Normalized-cut cost: " + str(normCut))
```

```
Normalized-cut cost: 0.39416666666666667
```

0.0.7 Question 7

```
In [32]: newCost = 0
          while 1:
              costs = []
              for n in nodes:
                  newNodes1 = nodes1.copy()
                  newNodes2 = nodes2.copy()

                  if n in nodes1:
                      newNodes1.remove(n)
                      newNodes2.append(n)
                      newDegrees1 = degrees1 - G.degree(n)
                      newDegrees2 = degrees2 + G.degree(n)
                  else:
                      newNodes2.remove(n)
                      newNodes1.append(n)
                      newDegrees2 = degrees2 - G.degree(n)
                      newDegrees1 = degrees1 + G.degree(n)
```

```
        cuttedEdges = sum([1 for e in edges
                         if (e[0] in newNodes1 and e[1] in newNodes2)
                         or (e[0] in newNodes2 and e[1] in newNodes1)])
        costs.append([n, cuttedEdges/2*(1/newDegrees1 + 1/newDegrees2)])

    costs = sorted(costs, key=lambda x:x[1])
    newCost = costs[0][1]
    if costs[0][0] in nodes1:
        nodes1.remove(costs[0][0])
        nodes2.append(costs[0][0])
        degrees1 = degrees1 - G.degree(costs[0][0])
        degrees2 = degrees2 + G.degree(costs[0][0])
    else:
        nodes2.remove(costs[0][0])
        nodes1.append(costs[0][0])
        degrees2 = degrees2 - G.degree(costs[0][0])
        degrees1 = degrees1 + G.degree(costs[0][0])

    nodes1.sort()
    nodes2.sort()

    if newCost > normCut:
        break
    else:
        normCut = newCost
```

```
In [33]: print(nodes1)
```

```
[697, 703, 708, 713, 719, 745, 747, 753, 769, 772, 774, 800, 803, 805, 810,
 811, 819, 823, 828, 830, 840, 856, 869, 880, 890]
```

```
In [34]: print(nodes2)
```

```
[729, 798, 804, 825, 861, 863, 864, 876, 878, 882, 884, 886, 888, 889, 893]
```

```
In [35]: print("The new normalized cut cost is " + str(normCut))
```

```
The new normalized cut cost is 0.09817045961624274
```

0.0.8 Question 8

```
In [36]: nodes1 = nodes[:len(nodes)//2]
         degrees1 = sum([G.degree(v) for v in nodes1])
         nodes2 = nodes[len(nodes)//2:]
         degrees2 = sum([G.degree(v) for v in nodes2])
```

```
In [37]: def modularity(c1, c2):
             e00 = sum([1 for e in edges if e[0] in c1 and e[1] in c1])/len(edges)
             e11 = sum([1 for e in edges if e[0] in c2 and e[1] in c2])/len(edges)

             a0 = 0
             a1 = 0
             for e in edges:
                 if(e[0] in c1):
                     a0 = a0 + 1
                 else:
                     a1 = a1 + 1

                 if(e[1] in c1):
                     a0 = a0 + 1
                 else:
                     a1 = a1 + 1
             a0 = a0/(2*len(edges))
             a1 = a1/(2*len(edges))

             return e00 - a0*a0 + e11 - a1*a1

In [38]: actualModularity = modularity(nodes1, nodes2)
         newModularity = 1
         while 1:
             modularities = []
             for n in nodes:
                 newNodes1 = nodes1.copy()
                 newNodes2 = nodes2.copy()

                 if n in nodes1:
                     newNodes1.remove(n)
                     newNodes2.append(n)
                     newDegrees1 = degrees1 - G.degree(n)
                     newDegrees2 = degrees2 + G.degree(n)
                 else:
                     newNodes2.remove(n)
                     newNodes1.append(n)
                     newDegrees2 = degrees2 - G.degree(n)
                     newDegrees1 = degrees1 + G.degree(n)

                 modularities.append([n, modularity(newNodes1, newNodes2)])

             modularities = sorted(modularities, key=lambda x:x[1])
             newModularity = modularities[0][1]

             if modularities[0][0] in nodes1:
                 nodes1.remove(modularities[0][0])
                 nodes2.append(modularities[0][0])
```

```
        degrees1 = degrees1 - G.degree(modularities[0][0])
        degrees2 = degrees2 + G.degree(modularities[0][0])
    else:
        nodes2.remove(modularities[0][0])
        nodes1.append(modularities[0][0])
        degrees2 = degrees2 - G.degree(modularities[0][0])
        degrees1 = degrees1 + G.degree(modularities[0][0])

    nodes1.sort()
    nodes2.sort()

    if newModularity > actualModularity:
        break
    else:
        actualModularity = newModularity
```

```
In [39]: print(nodes1)
```

```
[697, 703, 708, 729, 745, 769, 772, 774, 803, 804, 810, 811, 819, 823, 825, 830, 863, 864,
 876, 889, 893]
```

```
In [40]: print(nodes2)
```

```
[713, 719, 747, 753, 798, 800, 805, 828, 840, 856, 861, 869, 878, 880, 882, 884, 886, 888, 890]
```

```
In [41]: print("The new modularity is " + str(actualModularity))
```

```
The new modularity is -0.11372933884297518
```