Exercise 4

Applications of Data Analysis

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1 DATA PREPROCESSING AND CREATING DISTANCE MATRIX

Data was given in three csv-files. We read the input data in *x*, output data in *y* and coordinates in *z*. Also the input data is standardized and stored into *stdX*.

```
basepath = os.path.dirname(__file__)
inputpath = os.path.abspath(os.path.join(basepath, "Data4/INPUT.csv"))
outputpath = os.path.abspath(os.path.join(basepath, "Data4/OUTPUT.csv"))
coordinatespath = os.path.abspath(os.path.join(basepath,
"Data4/COORDINATES.csv"))

x = np.genfromtxt(inputpath, delimiter=',')
y = np.genfromtxt(outputpath, delimiter=',')
z = np.genfromtxt(coordinatespath, delimiter=',')

xArr = np.asarray(x)
stdX = (xArr - xArr.mean()) / xArr.std()
```

Distances between every pair of points has stored into distance matrix. M_{ij} is euclidean distance between *i*th and *j*th point in data. If i=j, the M_{ij} is set to -1.

```
def calculateDistanceMatrix():
    distanceMatrix = []
    for i in range(len(z)):
        xAxis = []
        for j in range(len(z)):
            if i == j:
                xAxis.append(-1.0)
            else:
                xAxis.append(ssd.euclidean(z[i], z[j]))
        distanceMatrix.append(xAxis)

    return distanceMatrix
```

2 FINDING OUT VALUES IN DEADZONE

Method *calculateDeadZone* finds 10 nearest points (where distance larger or equal to 0.0) for every datapoint and distance to those points -1. Thus our implementation of leave-on-out cross-validation ignores those points (see below).

```
def calculateDeadZone(matrix):
    for i in range(len(matrix)):
        xAxis = matrix[i]
        for _ in range(10):
            minIndex = xAxis.index(min(filter(lambda x:x>=0.0, xAxis)))
            xAxis[minIndex] = -1.0

    return matrix
```

3 CALCULATING 5-NEAREST-NEIGHBOR AND PREDICTING LABEL

Distances between two features is calculated only if the M_{ij} is larger or equals with 0. This limitation is done because, we need to leave test instance out of calculation and also every features that includes in deadzone. Distance for feature with itself and features in deadzone is set to -1. The method return k-nearest neighbor. The value of k is given in argument and in this case it is 5.

```
def inferNeighbors(trainSet, testInstance, labels, k, distRow):
    distances = []
    for x in range(len(trainSet)):
        if distRow[x] >= 0.0:
             distances.append((ssd.euclidean(trainSet[x], testInstance),
             labels[x]))

    distances.sort(key=operator.itemgetter(0))
    return distances[0:k]
```

The predicted value for the test instance is mean value of the neigbors classes.

```
def chooseMajorityLabel(neighbors, k):
    predictedOutcome = []
    sumOfMod = 0.0
    for i in range(len(neighbors)):
        sumOfMod = sumOfMod + neighbors[i][1]
    predictedOutcome.append(sumOfMod/k)

    return predictedOutcome
```

4 LEAVE-ONE-OUT CROSS-VALIDATION

Leave-one-out cross-validation – method gets as arguments the number of nearest neighbor to consider as k and distance matrix, which includes distances between every pair of points.

Method takes once every instance from training set to test set and calculates neighbors for it. Predicted label for test instance is calculated based on neighbors and the label is added to the list of every predictions made through calculation.

After that c-index is calculated based on pseudo-code we got in last exercise (Third Exercise: Prediction of metal ion content from multi-parameter data).

```
def LooCV(k, distanceMatrix):
    yPredictions = []
    for i in range(len(stdX)):
        neighbors = inferNeighbors(stdX, stdX[i], y, k, distanceMatrix[i])
        yPredictions.append(chooseMajorityLabel(neighbors,k))

    cIndex = calculateCIndex(yPredictions, y)
    printCIndexes(cIndex)

    return cIndex
```

5 SUMMING ALL THE METHODS

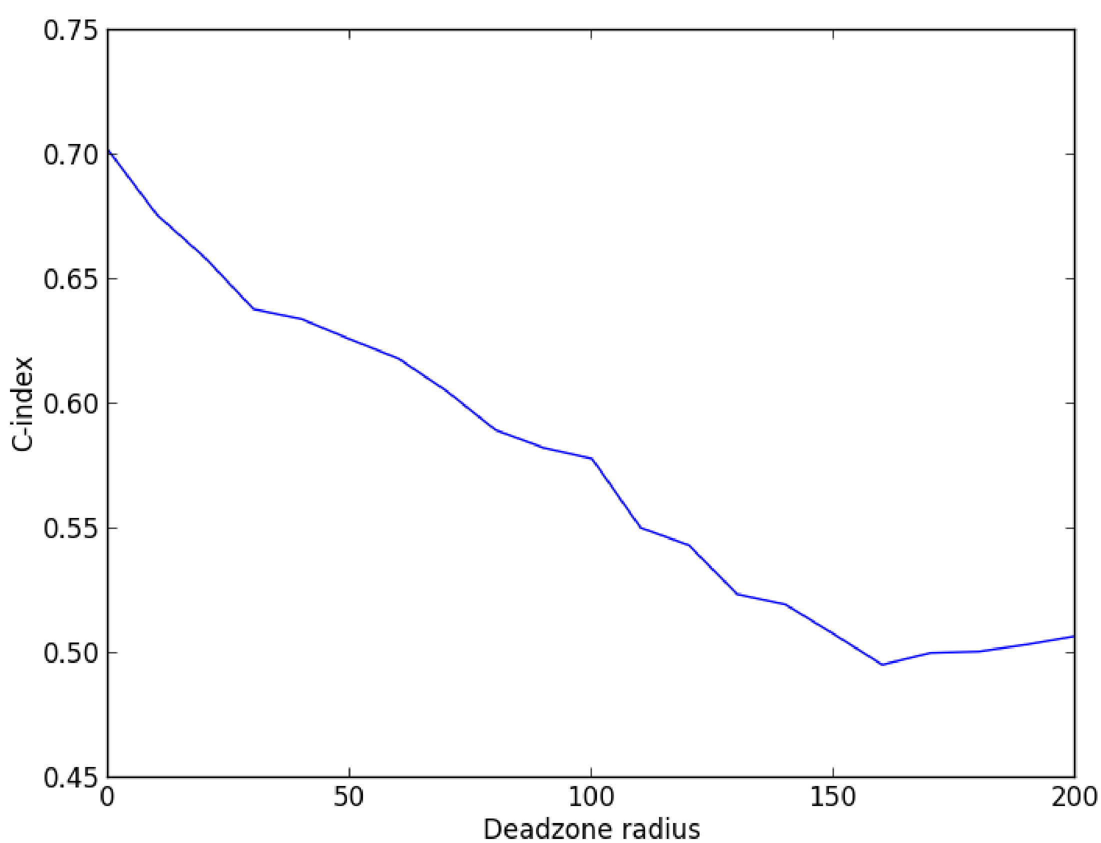
First of all the distance matrix is created. This matrix is used and modified during calculation. Method calculates c-index for each of the deadzone radius cases using leave-one-out implementation (see above) with argument 5(-nearest-neighbor). After each deadzone radius cases (0,10,20…,200) distance matrix is modified by disabling next 10 nearest points. In first round it disables 1-10 nearest, in second round 11-20 and so on.

```
def main():
    startTime = int(round(time.time() * 1000))
    distanceMatrix = calculateDistanceMatrix()
    cIndexes = []
    deadZoneValues = []
    for i in range(21):
        print 'Leave-one-out CV with deadzone radius ' + str(i * 10) + ':'
        cIndexes.append(LooCV(5, distanceMatrix))
        deadZoneValues.append(i * 10)
        distanceMatrix = calculateDeadZone(distanceMatrix)

    endTime = int(round(time.time() * 1000))
    print 'Running time: ' + str(endTime - startTime) + 'ms'

    plotCIndexVsDeadZone(cIndexes, deadZoneValues)
```

All the used deadzone radius and c-indexes are plotted:



And same data as plotted above:

Leave-one-out CV with deadzone radius **0**: C-Index: 0.**701855867534**

Leave-one-out CV with deadzone radius **10**: C-Index: 0.**676058930829**

Leave-one-out CV with deadzone radius **20**: C-Index: 0.**658731830851**

Leave-one-out CV with deadzone radius **30**: C-Index: 0.**638168826969**

Leave-one-out CV with deadzone radius **40**: C-Index: 0.**634122722163**

Leave-one-out CV with deadzone radius **50**: C-Index: 0.**626040661936**

Leave-one-out CV with deadzone radius **60**: C-Index: 0.**618301230945**

Leave-one-out CV with deadzone radius **70**: C-Index: 0.**605187175657**

Leave-one-out CV with deadzone radius **80**: C-Index: 0.**589694664503**

Leave-one-out CV with deadzone radius **90**: C-Index: 0.**582504700215**

Leave-one-out CV with deadzone radius **100**: C-Index: 0.**578135914964**

Leave-one-out CV with deadzone radius **110**: C-Index: 0.**550505789349**

Leave-one-out CV with deadzone radius **120**: C-Index: 0.**543447067108**

Leave-one-out CV with deadzone radius **130**: C-Index: 0.**523801007659**

Leave-one-out CV with deadzone radius **140**: C-Index: 0.**519612461485**

Leave-one-out CV with deadzone radius **150**: C-Index: 0.**507752730185**

Leave-one-out CV with deadzone radius **160**: C-Index: 0.**495467424674**

Leave-one-out CV with deadzone radius **170**: C-Index: 0.**500218736745**

Leave-one-out CV with deadzone radius **180**: C-Index: 0.**500782202599**

Leave-one-out CV with deadzone radius **190**: C-Index: 0.**503624030384**

Leave-one-out CV with deadzone radius **200**: C-Index: 0.**507006575402**

6 CODE

```python
'''

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Task steps:

1. Implement a Leave-One-Out cross validation with deadzone radius R = 0, 10, 20,
..., 200. So you will do 21 analyses in total here.
    Use 5-nearest neighbor as the prediction method. Remember normalization.

2. Calculate the C-index value for each of the deadzone radius cases.

3. Plot the C-index vs. Deadzone radius in a graph to visualize, how the prediction
performance changes with the deadzone radius.
    Set Y-axis to be the C-index and X-axis to be Deadzone radius

4. Return your implementation and the graph in a written report.

'''

import os
import operator
import scipy.spatial.distance as ssd
import numpy as np
import matplotlib.pyplot as pp
import time

if __name__ == '__main__':
    pass

basepath = os.path.dirname(__file__)
inputpath = os.path.abspath(os.path.join(basepath, "Data4/INPUT.csv"))
outputpath = os.path.abspath(os.path.join(basepath, "Data4/OUTPUT.csv"))
coordinatespath = os.path.abspath(os.path.join(basepath, "Data4/COORDINATES.csv"))

x = np.genfromtxt(inputpath, delimiter=',')
y = np.genfromtxt(outputpath, delimiter=',')
z = np.genfromtxt(coordinatespath, delimiter=',')

xArr = np.asarray(x)
stdX = (xArr - xArr.mean()) / xArr.std()


def calculateDistanceMatrix():
    distanceMatrix = []
    for i in range(len(z)):
        xAxis = []
        for j in range(len(z)):
            if i == j:
                xAxis.append(-1.0)
```

```python
            else:
                xAxis.append(ssd.euclidean(z[i], z[j]))
        distanceMatrix.append(xAxis)

    return distanceMatrix

def calculateCIndex(predictions, labels):
    n = 0
    h_sum = 0
    for i in range(len(labels)):
        t = labels[i]
        p = predictions[i]
        for j in range(i+1,len(labels)):
            nt = labels[j]
            np = predictions[j]
            if t != nt:
                n = n + 1
                if (p < np and t < nt) or (p > np and t > nt):
                    h_sum = h_sum + 1
                elif (p < np and t > nt) or (p > np and t < nt):
                    h_sum = h_sum + 0
                elif (p == np):
                    h_sum = h_sum + 0.5

    if n == 0:
        return 0
    else:
        return h_sum/n

def LooCV(k, distanceMatrix):
    yPredictions = []
    for i in range(len(stdX)):
        neighbors = inferNeighbors(stdX, stdX[i], y, k, distanceMatrix[i])
        yPredictions.append(chooseMajorityLabel(neighbors,k))

    cIndex = calculateCIndex(yPredictions, y)
    printCIndexes(cIndex)

    return cIndex

def chooseMajorityLabel(neighbors, k):
    predictedOutcome = []
    sumOfMod = 0.0
    for i in range(len(neighbors)):
        sumOfMod = sumOfMod + neighbors[i][1]
    predictedOutcome.append(sumOfMod/k)

    return predictedOutcome


def inferNeighbors(trainSet, testInstance, labels, k, distRow):
    distances = []
    for x in range(len(trainSet)):
        if distRow[x] >= 0.0:
            distances.append((ssd.euclidean(trainSet[x], testInstance), labels[x]))
```

```python
    distances.sort(key=operator.itemgetter(0))
    return distances[0:k]

def printCIndexes(cIndex):
    print 'C-Index: {a}'.format(a=cIndex)
    print

def calculateDeadZone(matrix):
    for i in range(len(matrix)):
        xAxis = matrix[i]
        for _ in range(10):
            minIndex = xAxis.index(min(filter(lambda x:x>=0.0, xAxis)))
            xAxis[minIndex] = -1.0

    return matrix

def plotCIndexVsDeadZone(cIndexes, deadZoneValues):
    pp.ylabel('C-index')
    pp.xlabel('Deadzone radius')
    pp.plot(deadZoneValues, cIndexes)
    pp.show()

def main():
    startTime = int(round(time.time() * 1000))
    distanceMatrix = calculateDistanceMatrix()
    cIndexes = []
    deadZoneValues = []
    for i in range(21):
        print 'Leave-one-out CV with deadzone radius ' + str(i * 10) + ':'
        cIndexes.append(LooCV(5, distanceMatrix))
        deadZoneValues.append(i * 10)
        distanceMatrix = calculateDeadZone(distanceMatrix)

    endTime = int(round(time.time() * 1000))
    print 'Running time: ' + str(endTime - startTime) + 'ms'

    plotCIndexVsDeadZone(cIndexes, deadZoneValues)

main()
```