Exercise 6

Applications of Data Analysis

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1 VARIANCE OF CROSS-VALIDATION

```
def nonSignalCV(size):
    predictions = []
    cIndexes = []

    for _ in range(100):
        features, labels = generateRandomData(size)
        for j in range(len(features)):
            predictions.append(leaveOneOutWithKNN(features, labels, j))
        cIndexes.append(calculateCIndex(predictions, labels))
        predictions = []
    mean, variance = calculateCIndexMeanAndVariance(cIndexes)
    performance = inferPerformance(cIndexes) * 100

    print 'Random data matrix size: ' + str(size)
    print 'Mean: ' + str(mean)
    print 'Variance: ' + str(variance)
    print '%-tage of C-Indexes over 0.7: ' + str(performance) + '%'
    print
    print

    pp.hist(cIndexes, 10)
    pp.xlabel('C-Index')
    pp.ylabel('Frequency')
    pp.show()
```

1.1 GENERATING DATA

The method generates random features and for each of them a label. Feature values are between 1 and 49 and labels are 1 or 0. Half of the labels have value of 1. Features and labels don’t correlate in any way because data is randomized separately.

```
def generateRandomData(size):
    features = []
    labels = []

    half = size / 2

    for i in range(size):
        features.append([rand(1, 50)])
        if i < half:
            labels.append(0)
        else:
            labels.append(1)

    shuf(labels)

    return features, labels
```

1.2 LEAVE-ONE-OUT WITH K-NEAREST NEIGHBOR

The test instance is removed from the feature and label data and we used scipy's method to calculate 3-nearest neighbor. The method returns the prediction based on classifier model.

```
def leaveOneOutWithKNN(features, labels, indexOfTest):
    featuresTemp = list(features)
    labelsTemp = list(labels)
    testInstance = features[indexOfTest]

    del featuresTemp[indexOfTest]
    del labelsTemp[indexOfTest]

    neigh = KNeighborsClassifier(n_neighbors=3)
    neigh.fit(featuresTemp, labelsTemp)

    return neigh.predict(testInstance)
```

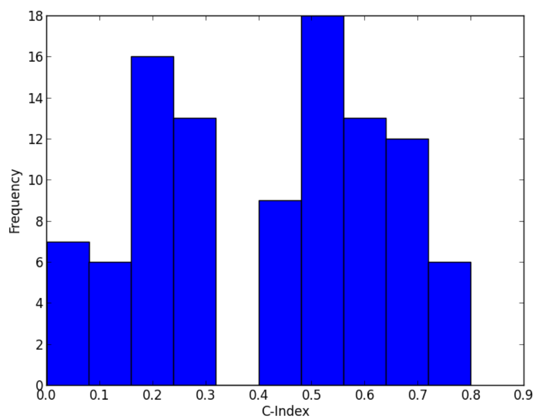
1.3 RESULTS

```
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 calculateCIndexMeanAndVariance(cIndexes):
    mean = np.mean(cIndexes)
    variance = np.mean((cIndexes - mean)**2)

    return mean, variance

def inferPerformance(cIndexes):
    count = 0.0
    for i in range(len(cIndexes)):
        if (cIndexes[i] > 0.7):
            count = count + 1.0

    return count / len(cIndexes)
```

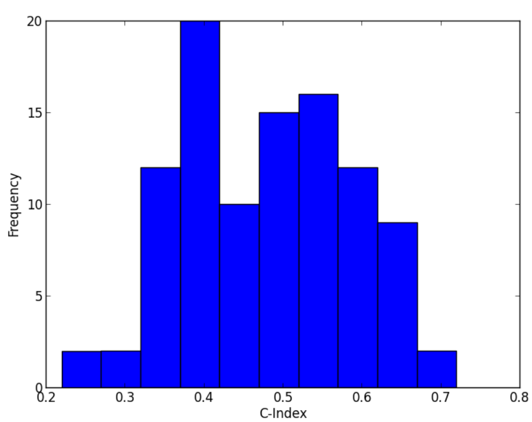
First of all c-indexes are calculated and stored into array. Then the mean and variance values are calculated from this array. Also percentage of c-indexes over 0.7 is calculated. The c-indexes are plotted as a histogram.

Non-signal data learning
Random data in range (1, 49)
Labels are binary (0, 1)

Random data matrix size: 10
Mean: 0.413
Variance: 0.051531
%-tage of C-Indexes over 0.7: 6.0%

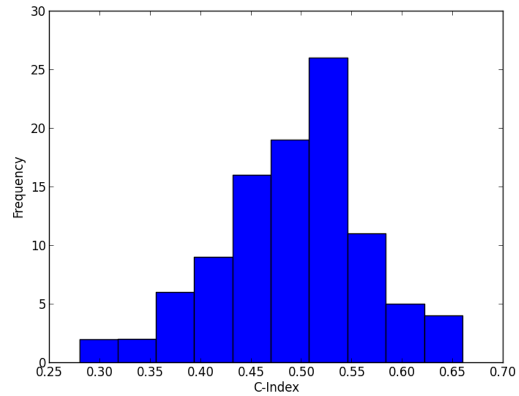


Random data matrix size: 50
Mean: 0.4814
Variance: 0.01101804
%-tage of C-Indexes over 0.7: 1.0%

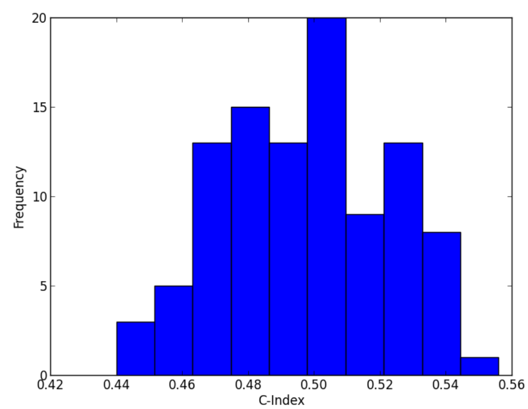


Random data matrix size: 100
Mean: 0.4933
Variance: 0.00522411

%-tage of C-Indexes over 0.7: 0.0%



Random data matrix size: 500
Mean: 0.49636
Variance: 0.0006244304
%-tage of C-Indexes over 0.7: 0.0%



1.4 ANALYSING THE RESULTS

When the data size is increasing the mean value stabilizes near 0.5, giving as a hint that the data is random/non-signal. And also the variance is decreasing as data size is increasing. This can be also seen from the histograms.

2 MIS-USING FEATURE SELECTION

```
def featureSelectedCV(rightWay):
    features, labels = generateLoadsOfRandomData()

    predictions = []

    if not rightWay:
        bestFeatures, labels = selectBestCorrelations(features, labels, 0,
rightWay, 10)

    for i in range(len(features)):
        if rightWay:
            bestFeatures, labels = selectBestCorrelations(features, labels,
i, rightWay, 10)
        predictions.append(leaveOneOutWithKNN(bestFeatures, labels, i))

    if not rightWay:
        print 'C-Index (wrong way): ' + str(calculateCIndex(predictions,
labels))
    else:
        print 'C-Index (right way): ' + str(calculateCIndex(predictions,
labels))
```

Main method gets a Boolean value as an argument, which tells whether to include the test instance in feature selection or not. Method uses same methods for predicting labels and calculating the c-index as the first assignment.

First we need to generate random data with sample size of 50 and including 1000 features. Labels are binaries and divides equally.

```
def generateLoadsOfRandomData():
    features = []
    labels = []

    for i in range(50):
        col = []
        if (i < 25):
            labels.append(0)
        else:
            labels.append(1)
        for _ in range(1000):
            col.append(rand(1, 50))
        features.append(col)

    shuf(labels)

    return features, labels
```

2.1 SELECTING 10 BEST FEATURES

At first method leaves out test instance if the Boolean argument (rightWay) is true. Otherwise this step is not included. Method uses scipy.stats.Kendalltau to calculate correlations between each column and labels. Correlation values are sorted in decreasing order and 10 features mapped to highest correlation values are returned.

```python
def selectBestCorrelations(features, labels, i, rightWay, selectCount):
    tauVals = []
    bestFeatures = []
    features = np.array(features)
    if rightWay:
        tempFeatures = np.array(filterTestInstance(features, i))
        tempLabels = np.array(filterTestInstance(labels, i))
    else:
        tempFeatures = features
        tempLabels = labels

    for i in range(1000):
        tauVal, _ = tau(tempFeatures[:,i], tempLabels)
        tauVals.append((abs(tauVal), i))

    tauVals.sort(key = operator.itemgetter(0))
    tauVals = tauVals[::-1]
    tauVals = tauVals[:10]
    for i in range(len(tauVals)):
        bestFeatures.append(features[:,tauVals[i][1]])

    return np.transpose(bestFeatures), labels
```

2.2 ANALYSING THE RESULTS

Mis-using feature selection
Random data in range (1, 49)
Labels are binary (0, 1)

C-Index (wrong way): 0.78
C-Index (right way): 0.28

Using the wrong way the results are biased because the test instance is included in selecting best features. Thus the results seem good as c-index is over 0.7. This happens because method chooses better features knowing the test instance also.

3 CODE

```
'''
```

```python
Authors: Marco Willgren, 502606
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'''
from sklearn.neighbors import KNeighborsClassifier
from random import randint as rand
from random import shuffle as shuf
import numpy as np
from matplotlib import pyplot as pp
from scipy.stats import kendalltau as tau
import operator

if __name__ == '__main__':
    pass

def generateRandomData(size):
    features = []
    labels = []

    half = size / 2

    for i in range(size):
        features.append([rand(1, 50)])
        if i < half:
            labels.append(0)
        else:
            labels.append(1)

    shuf(labels)

    return features, labels

def generateLoadsOfRandomData():
    features = []
    labels = []

    for i in range(50):
        col = []
        if (i < 25):
            labels.append(0)
        else:
            labels.append(1)
        for _ in range(1000):
            col.append(rand(1, 50))
        features.append(col)

    shuf(labels)

    return features, labels

def selectBestCorrelations(features, labels, i, rightWay, selectCount):
    tauVals = []
    bestFeatures = []
    features = np.array(features)
    if rightWay:
```

```python
        tempFeatures = np.array(filterTestInstance(features, i))
        tempLabels = np.array(filterTestInstance(labels, i))
    else:
        tempFeatures = features
        tempLabels = labels

    for i in range(1000):
        tauVal, _ = tau(tempFeatures[:,i], tempLabels)
        tauVals.append((abs(tauVal), i))

    tauVals.sort(key = operator.itemgetter(0))
    tauVals = tauVals[::-1]
    tauVals = tauVals[:10]
    for i in range(len(tauVals)):
        bestFeatures.append(features[:,tauVals[i][1]])

    return np.transpose(bestFeatures), labels


def leaveOneOutWithKNN(features, labels, indexOfTest):
    featuresTemp = list(features)
    labelsTemp = list(labels)
    testInstance = features[indexOfTest]

    del featuresTemp[indexOfTest]
    del labelsTemp[indexOfTest]

    neigh = KNeighborsClassifier(n_neighbors=3)
    neigh.fit(featuresTemp, labelsTemp)

    return neigh.predict(testInstance)

def nonSignalCV(size):
    predictions = []
    cIndexes = []

    for _ in range(100):
        features, labels = generateRandomData(size)
        for j in range(len(features)):
            predictions.append(leaveOneOutWithKNN(features, labels, j))
        cIndexes.append(calculateCIndex(predictions, labels))
        predictions = []
    mean, variance = calculateCIndexMeanAndVariance(cIndexes)
    performance = inferPerformance(cIndexes) * 100

    print 'Random data matrix size: ' + str(size)
    print 'Mean: ' + str(mean)
    print 'Variance: ' + str(variance)
    print '%-tage of C-Indexes over 0.7: ' + str(performance) + '%'
    print
    print

    pp.hist(cIndexes, 10)
    pp.xlabel('C-Index')
    pp.ylabel('Frequency')
```

```
    pp.show()

def calculateCIndexMeanAndVariance(cIndexes):
    mean = np.mean(cIndexes)
    variance = np.mean((cIndexes - mean)**2)

    return mean, variance

def inferPerformance(cIndexes):
    count = 0.0
    for i in range(len(cIndexes)):
        if (cIndexes[i] > 0.7):
            count = count + 1.0

    return count / len(cIndexes)

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 filterTestInstance(listA, i):
    listTemp = list(listA)
    del listTemp[i]
    return listTemp

def featureSelectedCV(rightWay):
    features, labels = generateLoadsOfRandomData()

    predictions = []

    if not rightWay:
        bestFeatures, labels = selectBestCorrelations(features, labels, 0, rightWay,
10)

    for i in range(len(features)):
        if rightWay:
```

```
            bestFeatures, labels = selectBestCorrelations(features, labels, i, 
rightWay, 10)
        predictions.append(leaveOneOutWithKNN(bestFeatures, labels, i))

    if not rightWay:
        print 'C-Index (wrong way): ' + str(calculateCIndex(predictions, labels))
    else:
        print 'C-Index (right way): ' + str(calculateCIndex(predictions, labels))

def printNSDHeader():
    print 'Non-signal data learning'
    print 'Random data in range (1, 49)'
    print 'Labels are binary (0, 1)'
    print '-----------------------------'
    print
    print

def printFSHeader():
    print 'Mis-using feature selection'
    print 'Random data in range (1, 49)'
    print 'Labels are binary (0, 1)'
    print '-----------------------------'
    print
    print

def main():
    printNSDHeader()
    nonSignalCV(10)
    nonSignalCV(50)
    nonSignalCV(100)
    nonSignalCV(500)

    printFSHeader()
    featureSelectedCV(False)
    featureSelectedCV(True)

main()
```