

CS486 Assignment 3

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Part A:

Q1: The construction of factor and the function needed are

in the file 'factor.py' :

```
from math import log10, floor

class Factor(object):
    # width during formatting
    FORMAT_WIDTH = 10
    # round up to roundTo decimal places
    ROUNDTO = 3

    # round up to n significant figures
    @staticmethod
    def significant(x):
        return round(x, -int(floor(log10(x))-(Factor.ROUNDTO-1)))

    def __init__(self, varList, varValues, mappedValues):
        self.factorTable = dict()
        self.mappedValues = mappedValues
        for i in xrange(0, len(varList)):
            self.factorTable[varList[i]] = varValues[i]

    # Restrict this factor on a variable with a particular value
    def restrict(self, variable, value):
        # search all the positions where value of indicated variable satisfy the parameter
        # 'value'
        index = [i for i, val in enumerate(self.factorTable[variable]) if val == value]
```

```

# firstly we take out the 'column' from the factorTable to continue restrict operation
del self.factorTable[variable]

# then we do the restriction operation
variables = self.factorTable.keys()

restrictVars = map(lambda var: [val for i, val in enumerate(self.factorTable[var]) if i in
index], variables)

self.mappedValues = [val for i, val in enumerate(self.mappedValues) if i in index]
for i in xrange(0, len(variables)):
    self.factorTable[variables[i]] = restrictVars[i]

# compute the multiplication of two factors
@staticmethod
def multiply(factorA, factorB):
    # get the variables list of each factor
    factorA_Vars = factorA.factorTable.keys()
    factorB_Vars = factorB.factorTable.keys()

    # figure out the variables which are common for these two factors and assign them
into newVars firstly
    newVars = [var for var in factorA_Vars if var in factorB_Vars]

    # select the rows in factorB that has to be multiplied with the rows in factorA
    multiply_A = [[] for i in xrange(len(factorA.mappedValues))]
    numMappedValues = 0
    for i in xrange(len(multiply_A)):
        for j in xrange(len(factorB.mappedValues)):
            sameCommonValues = True

            # we only multiply the tuple with the same values of common variables
            for var in newVars:
                if factorA.factorTable[var][i] != factorB.factorTable[var][j]:
                    sameCommonValues = False
                    break

            # now the Common Variables should have the same values

```

```

        if sameCommonValues:
            multiply_A[i].append(j)
            numMappedValues += 1

# now the newVars should contain the union of the two factors
newVars.extend([var for var in factorA_Vars if var not in newVars])
newVars.extend([var for var in factorB_Vars if var not in newVars])

newValues = [[] for i in xrange(len(newVars))]
multiplyValues = []

tuples = tuple(enumerate(newVars))

# for each row in factorA
for row in xrange(len(multiply_A)):
    # for each rows in factorB to be multiplied with a row in in factorA
    for row_in_factorB in multiply_A[row]:
        for i, var in tuples:
            # assign values of these variables row by row
            newValues[i].append(factorA.factorTable[var][row] if var in
factorA_Vars \
                                else factorB.factorTable[var][row_in_factorB])
            multiplyValues.append(Factor.significant(factorA.mappedValues[row] *
factorB.mappedValues[row_in_factorB]))

return Factor(newVars, newValues, multiplyValues)

# sum a variable in a factor
def sumout(self, variable):
    # notice that we should do nothing for a factor with only one variable
    if len(self.factorTable.keys()) == 1:
        return

```

```

# get the domain of the variable
domainOfVar = set(self.factorTable[variable])

# delete the column of this variable from table entirely
del self.factorTable[variable]

row_to_sum = []
allOfVars = self.factorTable.keys()
for i in xrange(len(self.mappedValues)):
    if i in row_to_sum:
        # if i already found should be sum, continue to next iteration
        continue

    limitOfMatch = len(self.mappedValues) / len(domainOfVar)

    for j in xrange(i+1, len(self.mappedValues)):
        # check if the remaining values of vars of two row are the same
        sameValues = True
        for var in allOfVars:
            if self.factorTable[var][i] != self.factorTable[var][j]:
                sameValues = False

        if sameValues and j not in row_to_sum:
            row_to_sum.append(j)
            limitOfMatch -= 1

        # if we already found pair of matches up to limitOfMatch
        if limitOfMatch == 0:
            break

newValues = [[] for i in xrange(len(allOfVars))]
# create a new list of mapped values with length
sumoutValues = []

```

```

lists = list(enumerate(allOfVars))
sumRowIndex = 0
for i in xrange(len(self.mappedValues)):

    if i in row_to_sum:
        continue

    for w, var in lists:
        newValues[w].append(self.factorTable[var][i])

    # add the rows as a sum of a kind of variable values
    sum = self.mappedValues[i]
    for j in xrange(0, len(domainOfVar)-1):
        sum+= self.mappedValues[row_to_sum[sumRowIndex]]
        sumRowIndex+= 1

    sumoutValues.append(sum)

for j, var in lists:
    # clear former values
    del self.factorTable[var][:]
    self.factorTable[var].extend(newValues[j])

# clear old mappedValues
del self.mappedValues[:]
self.mappedValues.extend(sumoutValues)

def normalize(self):
    totalMappedValues = sum(self.mappedValues)
    self.mappedValues[:] = map(lambda x: Factor.significant(x/totalMappedValues),
self.mappedValues)

```

```

@staticmethod
def inference(factorList, queryVariables, orderedListOfHiddenVariables, evidenceList):
    # figure out the variables which are in the query and evidence from
orderedListOfHiddenVariables
    step = 0
    if len(evidenceList) > 0:
        evidenceOfVars = zip(*evidenceList)[0]
    else:
        evidenceOfVars = []
    orderedListOfHiddenVariables = filter(lambda x: x not in queryVariables \
and x not in evidenceOfVars,
orderedListOfHiddenVariables)

    for evidence in evidenceList:
        for factor in factorList:
            # if the evidence variable is in this factor, we should restrict them
            if evidence[0] in factor.factorTable.keys():
                factor.restrict(evidence[0], evidence[1])

    evidences = reduce(lambda x,y: '{!s}, {!s}'.format(x,y), evidenceList) if
len(evidenceList) > 0 else 'nothing'
    print ("step ",step)
    step += 1
    Factor.textFormattedPrint('Restricting factors on evidence {!s}'.format(evidences), 50,
factorList)

    for hiddenVariable in orderedListOfHiddenVariables:
        factorsWithHiddenVar = []
        for factor in factorList:

```

```

        if hiddenVariable in factor.factorTable.keys():
            factorsWithHiddenVar.append(factor)

# take out all the factors with a hidden variable from the list
factorList = filter(lambda x: x not in factorsWithHiddenVar, factorList)

# compute product of hidden variables
if len(factorsWithHiddenVar) > 0:
    print ("step ",step)
    step += 1
    Factor.textFormattedPrint('Summing over {!s}'.format(hiddenVariable), 30,
[]
                                multiplyFactor = reduce(Factor.multiply, factorsWithHiddenVar)
else:

    continue

    print ("step ",step)
    step += 1
    Factor.textFormattedPrint('Intermediate      multiply      factor      on
{!s}'.format(hiddenVariable),30,[multiplyFactor])

# do the sumout operation among the hidden variable on the product factor
print ("step ",step)
step += 1
multiplyFactor.sumout(hiddenVariable)
Factor.textFormattedPrint('Summing      out      variable
{!s}'.format(hiddenVariable),30,[multiplyFactor])

# insert the result back to the list
factorList.append(multiplyFactor)

# now the only issue we have is about factors with only the query variable, we

```

product them together

```
inferredFactor = reduce(Factor.multiply, factorList)
print ("step ",step)
step += 1
Factor.textFormattedPrint('multiplying factors with query variables: {!s}'.\
                           format(queryVariables),45,[inferredFactor])
```

```
# normalize stage
inferredFactor.normalize()
print ("step ",step)
step += 1
Factor.textFormattedPrint('Finally normalize the result',30,[inferredFactor])
```

```
def copy(self):
    valuesOfKey = self.factorTable.items()
    return Factor(map(lambda x: x[0], valuesOfKey), map(lambda x: x[1], valuesOfKey),
self.mappedValues)
```

delete operation which take out the 'column' in matrix

```
def __del__(self):
    del self.mappedValues
    self.factorTable.clear()
    del self.factorTable
```

used to get the string form of this factor

```
def __str__(self):
    formatting = ""
    variables = self.factorTable.keys()
    # create a format string to use
    for i in xrange(0, len(variables)+1):
```



```

        formatting+= '{!s:{width}}'
        if i == len(variables):
            formatting+= '\r\n'

    # create the formatted header
    returnValue = formatting.format('MappedVal', *variables,
width=Factor.FORMAT_WIDTH)

    zippedValues = zip(self.mappedValues, *map(lambda x: self.factorTable[x],
variables))

    # for each value create the formatted row
    for values in zippedValues:
        returnValue+= formatting.format(*values, width=Factor.FORMAT_WIDTH)

    return returnValue

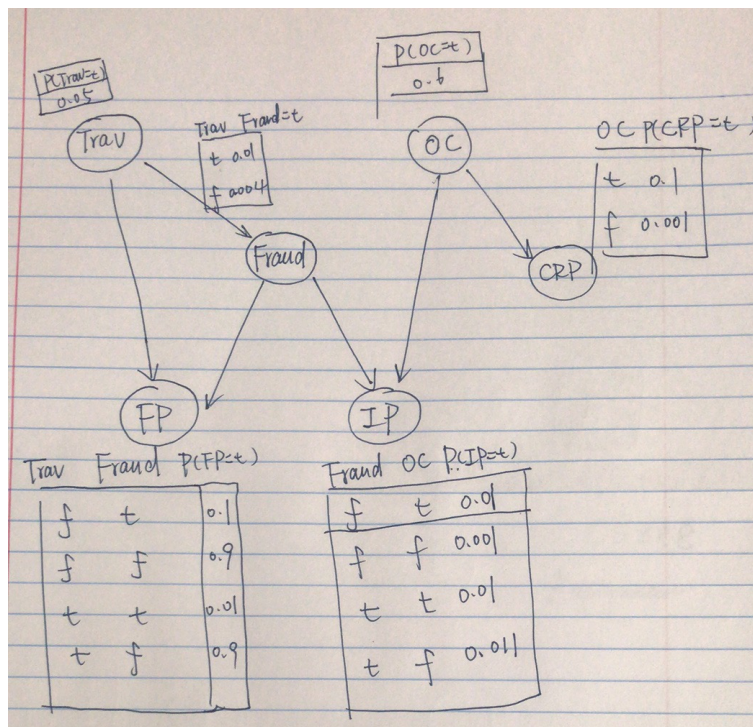
@staticmethod
def textFormattedPrint(statement, Num, factors):
    print statement, '\r'
    print '+' * Num, '\r'
    for factor in factors:
        print factor, '\r'

    print '+' * Num, '\r'

```

Q2: The construction of factor and the function needed are in the file 'factor.py' :

(a)



(b) the code :

```
1 from factor import Factor
2
3 def main():
4     hiddenVariables = ['Trav', 'FP', 'Fraud', 'IP', 'OC', 'CRP']
5     factorTrav = Factor(['Trav'], [['t', 'f']], [0.05, 0.95])
6     factorFraudTrav = Factor(['Fraud', 'Trav'], [['t', 't', 'f', 'f'], ['t', 'f', 't', 'f']], [0.01, 0.004, 0.99, 0.996])
7     factorFPFraudTrav = Factor(['FP', 'Fraud', 'Trav'], [['t', 't', 't', 't', 'f', 'f', 'f', 'f'],
8                                                         ['t', 't', 'f', 'f', 't', 't', 'f', 'f']],
9                               [0.9, 0.1, 0.9, 0.01, 0.1, 0.9, 0.1, 0.99])
10    factorIPFraudOC = Factor(['IP', 'Fraud', 'OC'], [['t', 't', 't', 't', 'f', 'f', 'f', 'f'],
11                                                    ['t', 't', 'f', 'f', 't', 't', 'f', 'f']],
12                            [0.02, 0.011, 0.01, 0.001, 0.98, 0.989, 0.99, 0.999])
13    factorCRPOC = Factor(['CRP', 'OC'], [['t', 't', 'f', 'f'], ['t', 'f', 't', 'f']], [0.1, 0.001, 0.9, 0.999])
14    factorOC = Factor(['OC'], [['t', 'f']], [0.6, 0.4])
15
16    copyFraudTrav = factorFraudTrav.copy()
17    copyIPFraudOC = factorIPFraudOC.copy()
18    copyOC = factorOC.copy()
19    copyTrav = factorTrav.copy()
20    copyCRPOC = factorCRPOC.copy()
21    copyFPFraudTrav = factorFPFraudTrav.copy()
22
23    Factor.inference([factorFraudTrav, factorTrav], ['Fraud'], hiddenVariables, [])
24    Factor.inference([copyTrav, copyFraudTrav, copyFPFraudTrav, copyIPFraudOC, copyOC, copyCRPOC],
25                    ['Fraud'], hiddenVariables, [['FP', 't'], ['CRP', 't'], ['IP', 'f']])
26
27 main()
```

now we can see the steps of two inference from the terminal:

```
[v1022-rn-76-14:a3partA chenyifei$ python q2b.py
('step ', 0)
Restricting factors on evidence nothing
++++
MappedVal Fraud      Trav
0.01      t          t
0.004     t          f
0.99      f          t
0.996     f          f

MappedVal Trav
0.05      t
0.95      f

++++
('step ', 1)
Summing over Trav
++++
('step ', 2)
Intermediate multiply factor on Trav
++++
MappedVal Fraud      Trav
0.0005     t          t
0.0038     t          f
0.0495     f          t
0.946      f          f

++++
('step ', 3)
Summing out variable Trav
++++
MappedVal Fraud
0.0043     t
0.9955     f

++++
('step ', 4)
multiplying factors with query variables: ['Fraud']
++++
MappedVal Fraud
0.0043     t
0.9955     f

++++
('step ', 5)
Finally normalize the result
++++
MappedVal Fraud
0.0043     t
0.996      f
```

```

+++++
('step ', 0)
Restricting factors on evidence ['FP', 't'], ['CRP', 't'], ['IP', 'f']
+++++
MappedVal Trav
0.05      t
0.95      f

MappedVal Fraud      Trav
0.01      t          t
0.004     t          f
0.99      f          t
0.996     f          f

MappedVal Fraud      Trav
0.9        t          t
0.1        t          f
0.9        f          t
0.01       f          f

MappedVal Fraud      OC
0.98       t          t
0.989      t          f
0.99       f          t
0.999      f          f

MappedVal OC
0.6        t
0.4        f

MappedVal OC
0.1        t
0.001      f

+++++
('step ', 1)
Summing over Trav
+++++
('step ', 2)
Intermediate multiply factor on Trav
+++++
MappedVal Fraud      Trav
0.00045   t          t
0.0446    f          t
0.00038   t          f
0.00946   f          f

+++++
('step ', 3)
Summing out variable Trav
+++++
MappedVal Fraud
0.00083    t
0.05406    f

+++++
('step ', 4)
Summing over OC
+++++
('step ', 5)
Intermediate multiply factor on OC
+++++
MappedVal Fraud      OC
0.0588      t          t
0.000396    t          f
0.0594      f          t
0.0004      f          f

```

```

+++++
('step ', 6)
Summing out variable OC
+++++
MappedVal Fraud
0.059196  t
0.0598    f

+++++
('step ', 7)
multiplying factors with query variables: ['Fraud']
+++++
MappedVal Fraud
4.91e-05  t
0.00323   f

+++++
('step ', 8)
Finally normalize the result
+++++
MappedVal Fraud
0.015     t
0.985     f

```

(c) The code:

```

1  from factor import Factor
2
3  def main():
4      hiddenVariables = ['Trav','FP','Fraud','IP','OC','CRP']
5      factorTrav = Factor(['Trav'], [['t','f']], [0.05,0.95])
6      factorFraudTrav = Factor(['Fraud','Trav'], [['t','t','f','f'], ['t','f','t','f']], [0.01,0.004,0.99,0.996])
7      factorFPFraudTrav = Factor(['FP','Fraud','Trav'], [['t','t','t','t','f','f','f','f'],
8                                                         ['t','t','f','f','t','t','f','f'],
9                                                         ['t','f','t','f','t','f','t','f']],
10                                     [0.9,0.1,0.9,0.01,0.1,0.9,0.1,0.99])
11      factorIPFraudOC = Factor(['IP','Fraud','OC'], [['t','t','t','t','f','f','f','f'],
12                                                         ['t','t','f','f','t','t','f','f'],
13                                                         ['t','f','t','f','t','f','t','f']],
14                                     [0.02,0.011,0.01,0.001,0.98,0.989,0.99,0.999])
15      factorCRPOC = Factor(['CRP','OC'], [['t','t','f','f'], ['t','f','t','f']], [0.1,0.001,0.9,0.999])
16      factorOC = Factor(['OC'], [['t','f']], [0.6,0.4])
17
18      Factor.inference([factorTrav,factorFraudTrav,factorFPFraudTrav,factorIPFraudOC,factorOC,factorCRPOC],
19                      ['Fraud'],hiddenVariables,['FP','t'],['CRP','t'],['IP','f'],['Trav','t'])
20
21  main()
22

```

steps:

```

[v1022-rn-76-14:a3partA chenylfei$ python q2c.py
('step ', 0)
Restricting factors on evidence ['FP', 't'], ['CRP', 't'], ['IP', 'f'], ['Trav',
't']
+++++
MappedVal
0.05

MappedVal Fraud
0.01 t
0.99 f

MappedVal Fraud
0.9 t
0.9 f

MappedVal Fraud OC
0.98 t t
0.989 t f
0.99 f t
0.999 f f

MappedVal OC
0.6 t
0.4 f

MappedVal OC
0.1 t
0.001 f

+++++
('step ', 1)
Summing over OC
+++++
('step ', 2)
Intermediate multiply factor on OC
+++++
MappedVal Fraud OC
0.0588 t t
0.000396 t f
0.0594 f t
0.0004 f f

+++++
('step ', 3)
Summing out variable OC
+++++
MappedVal Fraud
0.059196 t
0.0598 f

+++++
('step ', 4)
multiplying factors with query variables: ['Fraud']
+++++
MappedVal Fraud
2.66e-05 t
0.00267 f

+++++
('step ', 5)
Finally normalize the result
+++++
MappedVal Fraud
0.00986 t
0.99 f

+++++

```

(d) code:

```

1 from factor import Factor
2
3 ~ def main():
4     hiddenVariables = ['Trav','FP','Fraud','IP','OC','CRP']
5     factorTrav = Factor(['Trav'], [['t','f']], [0.05,0.95])
6     factorFraudTrav = Factor(['Fraud','Trav'], [['t','t','f','f'], ['t','f','t','f']], [0.01,0.004,0.99,0.996])
7 ~     factorFPFraudTrav = Factor(['FP','Fraud','Trav'], [['t','t','t','t','f','f','f','f'],
8     ['t','t','f','f','t','t','f','f'],
9     ['t','f','t','f','t','f','t','f']],
10    [0.9,0.1,0.9,0.01,0.1,0.9,0.1,0.99])
11 ~     factorIPFraudOC = Factor(['IP','Fraud','OC'], [['t','t','t','t','f','f','f','f'],
12    ['t','t','f','f','t','t','f','f'],
13    ['t','f','t','f','t','f','t','f']],
14    [0.02,0.011,0.01,0.001,0.98,0.989,0.99,0.999])
15     factorCRPOC = Factor(['CRP','OC'], [['t','t','f','f'], ['t','f','t','f']], [0.1,0.001,0.9,0.999])
16     factorOC = Factor(['OC'], [['t','f']], [0.6,0.4])
17
18
19     copyIPFraudOC = factorIPFraudOC.copy()
20     copyFraudTrav = factorFraudTrav.copy()
21     copyCRPOC = factorCRPOC.copy()
22     copyOC = factorOC.copy()
23     copyTrav = factorTrav.copy()
24     copyFPFraudTrav = factorFPFraudTrav.copy()
25
26 ~     Factor.inference([copyTrav, copyFraudTrav, copyFPFraudTrav, copyIPFraudOC, copyOC, copyCRPOC],
27    ['Fraud'], hiddenVariables, [['IP', 't']])
28 ~     Factor.inference([factorTrav, factorFraudTrav, factorFPFraudTrav, factorIPFraudOC, factorOC, factorCRPOC],
29    ['Fraud'], hiddenVariables, [['IP', 't'], ['CRP', 't']])
30
31
32     main()
33

```

steps:

```
[v1022-rn-76-14:a3partA chenylfei$ python q2d.py
('step ', 0)
Restricting factors on evidence ['IP', 't']
+++++
MappedVal Trav
0.05      t
0.95      f

MappedVal Fraud      Trav
0.01      t          t
0.004     t          f
0.99      f          t
0.996     f          f

MappedVal FP          Fraud      Trav
0.9         t          t          t
0.1         t          t          f
0.9         t          f          t
0.01        t          f          f
0.1         f          t          t
0.9         f          t          f
0.1         f          f          t
0.99        f          f          f

MappedVal Fraud      OC
0.02        t          t
0.011       t          f
0.01        f          t
0.001       f          f

MappedVal OC
0.6         t
0.4         f

MappedVal CRP          OC
0.1         t          t
0.001       t          f
0.9         f          t
0.999       f          f

('step ', 1)
Summing over Trav
+++++
('step ', 2)
Intermediate multiply factor on Trav
+++++
MappedVal FP          Fraud      Trav
0.00045      t          t          t
5e-05        f          t          t
0.0446       t          f          t
0.00495      f          f          t
0.00038      t          t          f
0.00342      f          t          f
0.00946      t          f          f
0.937        f          f          f

('step ', 3)
Summing out variable Trav
+++++
MappedVal FP          Fraud
0.00083      t          t
0.00347      f          t
0.05406      t          f
0.94195      f          f

('step ', 4)
Summing over FP
+++++
('step ', 5)
Intermediate multiply factor on FP
+++++
MappedVal FP          Fraud
0.00083      t          t
0.00347      f          t
0.05406      t          f
0.94195      f          f

('step ', 6)
Summing out variable FP
+++++
MappedVal Fraud
0.0043      t
0.99601     f

('step ', 7)
Summing over OC
+++++
('step ', 8)
Intermediate multiply factor on OC
+++++
MappedVal CRP          Fraud      OC
0.0012      t          t          t
0.0108      f          t          t
4.4e-06     t          t          f
0.0044      f          t          f
0.0006      t          f          t
0.0054      f          f          t
4e-07       t          f          f
0.0004      f          f          f

('step ', 9)
Summing out variable OC
+++++
MappedVal CRP          Fraud
0.0012044    t          t
0.0152       f          t
0.0006004    t          f
0.0058       f          f

('step ', 10)
Summing over CRP
+++++
('step ', 11)
Intermediate multiply factor on CRP
+++++
MappedVal CRP          Fraud
0.0012044    t          t
0.0152       f          t
0.0006004    t          f
0.0058       f          f

('step ', 12)
Summing out variable CRP
+++++
MappedVal Fraud
0.0164044    t
0.0064004    f

('step ', 13)
multiplying factors with query variables: ['Fraud']
+++++
MappedVal Fraud
7.05e-05     t
0.00637      f

('step ', 14)
Finally normalize the result
+++++
MappedVal Fraud
0.0109      t
0.989       f
```

PartB

Code :

```
preprocess.py
1 from sets import Set
2
3 # the function to produce the matrix from the content of the files
4 # which has the same functionality with load.m script in matlab
5
6 def setMatrix(data, label, numFeatures):
7     Matrix = []
8     #construct the matrix with the size [numArticle][numFeatures + 1 ]
9     #and assign the label value of each article is in the last column
10    with open(label, 'r') as f:
11        docId = 0
12        for line in f:
13            Matrix.append([0] * (numFeatures + 1))
14            Matrix[docId][-1] = int(line)
15            docId+= 1
16
17    #read the data file and record the words existence of each article in the matrix
18    with open(data, 'r') as f:
19        for line in f:
20            lineSplit = line.split()
21            fileId = int(lineSplit[0])
22            featureNum = int(lineSplit[1])
23            Matrix[fileId-1][featureNum-1] = 1
24
25    return Matrix
26
27 # obtain the arrays of numfeature and exactly words in correspond order
28 def readWords(haveDone):
29     numFeatures = 0
30     features = []
31     words = []
32     if haveDone:
33         featuresSet = Set(featuresSet)
34
35     with open('words.txt', 'r') as f:
36         for line in f:
37             if haveDone:
38                 features.add(numFeatures)
39             else:
40                 features.append(numFeatures)
41
42             numFeatures = numFeatures + 1
43             wordsSet.append(line.rstrip())
44
45     return (numFeatures, features, words)
46
47
48
49
50
51
52
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60
61
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```



```
main.py > No Selection
1 from __future__ import division
2 from naiveBayes import NaiveBayes
3 from preprocess import setMatrix, readWords
4
5 # implement the prediction
6 # and check the correction rate
7 def getAccuracy(learner, matrix):
8     numCorrectPredictions = 0
9     for rows in matrix:
10
11         if learner.predict(rows) == rows[-1]:
12             numCorrectPredictions += 1
13
14     return numCorrectPredictions/len(matrix)
15
16 def main():
17     numFeatures, featuresSet, wordsSet = readWords(False)
18     trainMatrix = setMatrix('trainData.txt', 'trainLabel.txt', numFeatures)
19     testMatrix = setMatrix('testData.txt', 'testLabel.txt', numFeatures)
20
21
22     naiveLearner = NaiveBayes (featuresSet, trainMatrix)
23     # get the accuracy for train and test file
24     trainAccuracy = getAccuracy(naiveLearner, trainMatrix)
25     testAccuracy = getAccuracy(naiveLearner, testMatrix)
26
27     print ("trainAccuracy: %s  testAccuracy: %d" %(trainAccuracy,testAccuracy))
28
29     naiveLearner.DiscriminativeWords(wordsSet)
30
31 main()
32
```

print out of code :

preprocess:

from sets import Set

the function to produce the matrix from the content of the files

which has the same functionality with load.m script in matlab

def setMatrix(data, label, numFeatures):

Matrix = []

#construct the matrix with the size [numArticle][numFeatures + 1]

#and assign the label value of each article is in the last column

with open(label, 'r') as f:

docId = 0

for line in f:

Matrix.append([0] * (numFeatures + 1))

Matrix[docId][-1] = int(line)

docId += 1

#read the data file and record the words existence of each article in the matrix

with open(data, 'r') as f:

```

    for line in f:

        lineSplit = line.split()

        fileID = int(lineSplit[0])

        featureNum = int(lineSplit[1])

        Matrix[fileID-1][featureNum-1] = 1

    return Matrix

# obtain the arrays of numfeature and exactly words in correspond order
def readWords(haveDone):

    numFeatures = 0

    features = []

    words = []

    if haveDone:

        featuresSet = Set(featuresSet)

    with open('words.txt', 'r') as f:

        for line in f:

            if haveDone:

                features.add(numFeatures)

            else:

                features.append(numFeatures)

            numFeatures = numFeatures + 1

            wordsSet.append(line.rstrip())

    return (numFeatures, features, words)

```

Naïvebayes

```
from math import log, fabs
```

```
from __future__ import division
```

```
import heapq
```

```
class NaiveBayes(object):
```

```
    # labbel
```

```
    ALTATHEISM = 1
```

```
    COMPGRAPHICS = 2
```

```
    def __init__(self, featuresSet, matrix):
```

```
        # get groups of Atheism and graphics separately
```

```
        Atheism = filter(lambda doc: doc[-1] == NaiveBayesLearner.ALTATHEISM, matrix)
```

```
        Graphics = filter(lambda doc: doc[-1] == NaiveBayesLearner.COMPGRAPHICS, matrix)
```

```
        # compute the prior probability
```

```
        self.priorAtheism = len(Atheism)/len(matrix)
```

```
        self.priorGraphics = len(Graphics)/len(matrix)
```

```
        # for each feature calculate the likelihood
```

```
        self.likelihoods = [(reduce(lambda x,y: (1 if y[feature] else 0) + x, Atheism, 0) + 1)/(len(Atheism) + 2),\
                             (reduce(lambda x,y: (1 if y[feature] else 0) + x, Graphics, 0) + 1)/(len(Graphics) + 2))\
                             for feature in featuresSet]
```

```
    def predict(self, doc):
```

```
        posteriorAtheism = log(self.priorAtheism)
```

```
        posteriorGraphics = log(self.priorGraphics)
```

```
        for i in xrange(0,len(self.likelihoods)):
```

```
            if doc[i]:
```

```
                posteriorAtheism += log(self.likelihoods[i][0])
```

```
            else:
```

```
                posteriorAtheism -= log(1-self.likelihoods[i][0])
```

```
            if doc[i]:
```

```
                posteriorGraphics += log(self.likelihoods[i][1])
```

```

        else:

            posteriorGraphics -= log(1-self.likelihoods[i][1])

        # now we return the result with higher ML

        return NaiveBayesLearner.ALATHEISM if posteriorAtheism >= posteriorGraphics else
NaiveBayesLearner.COMPGRAPHICS

# for question 2

def DiscriminativeWords(self, wordsSet):

    array = []

    # compute the absolute value of difference of likelihoods

    for i in xrange(0,len(self.likelihoods)):

        difference = fabs(log(self.likelihoods[i][0], 2) - log(self.likelihoods[i][1], 2))

        array.append((i,difference))

    # sort the result

    array.sort(lambda x,y: cmp(x[1],y[1]), None, True)

    for i in xrange(0, 10):

        print ("word: %s discrimination: %d" %(wordsSet[res[i][0]], res[i][1]))

```

main:

```

from __future__ import division

from naiveBayes import NaiveBayes

from preprocess import setMatrix, readWords


# implement the prediction

# and check the correction rate

def getAccuracy(learner, matrix):

    numCorrectPredictions = 0

    for rows in matrix:

        if learner.predict(rows) == rows[-1]:

            numCorrectPredictions+= 1

    return numCorrectPredictions/len(matrix)

```

```

def main():

    numFeatures, featuresSet, wordsSet = readWords(False)

    trainMatrix = setMatrix('trainData.txt', 'trainLabel.txt', numFeatures)

    testMatrix = setMatrix('testData.txt', 'testLabel.txt', numFeatures)

    naiveLearner = NaiveBayes (featuresSet, trainMatrix)

    # get the accuracy for train and text file

    trainAccuracy = getAccuracy(naiveLearner, trainMatrix)

    testAccuracy = getAccuracy(naiveLearner, testMatrix)

    print ("trainAccuracy: %s  testAccuracy: %d" %(trainAccuracy,testAccuracy))

    naiveLearner.DiscriminativeWords(wordsSet)

main

```

Question b

```

trainAccuracy: 0.92837  testAccuracy: 0.88967
word: graphics  discrimination: 6.38374874578
word: atheism  discrimination: 5.73389435561
word: religion  discrimination: 5.66678015975
word: moral  discrimination: 5.55986495583
word: keith  discrimination: 5.55986495583
word: evidence  discrimination: 5.55986495583
word: atheists  discrimination: 5.52239025041
word: god  discrimination: 5.45768456103
word: bible  discrimination: 5.40374575392
word: christian  discrimination: 5.36192557822

```

Question c

This assumption might be reasonable in some situations where the variables are not correlated firmly, and calculating the accurate result can be hard, therefore the choice of naïve Bayesian is reasonable.

However, we do production directly for conditional probabilities, which is not accurate. we saw that in this part of assignment the algorithm is not that good for estimation when faced with test data.

Question d

Suppose we have a dataset \mathbf{e} , where the i^{th} data assign a values \mathbf{x}_i to observed variables \mathbf{X} , leaving \mathbf{Z} latent variables (with values \mathbf{z}_j) unassigned, then

Recall: Bayes Net Maximum Likelihood (Complete data - $\mathbf{Z} = \{\}$)

$$\theta_{V=true, pa(V)=\mathbf{v}} = \frac{\text{number in } \mathbf{e} \text{ with } (V = true \wedge pa(V) = \mathbf{v})}{\text{number in } \mathbf{e} \text{ with } pa(V) = \mathbf{v}}$$

Now: Bayes Net Expectation Maximization (incomplete data)

Start with some guess for θ ,

E Step: Compute weights for each data \mathbf{x}_i and latent variable(s) value(s) \mathbf{z}_j (using e.g. variable elimination)

$$w_{ij} = P(\mathbf{z}_j | \theta, \mathbf{x}_i)$$

M Step: Update parameters:

$$\theta_{V=true, pa(V)=\mathbf{v}} = \frac{\sum_{ij} w_{ij} | V = true \wedge pa(V) = \mathbf{v} \text{ in } \{\mathbf{x}_i, \mathbf{z}_j\}}{\sum_{ij} w_{ij} | pa(V) = \mathbf{v} \text{ in } \{\mathbf{x}_i, \mathbf{z}_j\}}$$