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MACHINE LEARNING LAB REPORT

1) Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a .CSV file.

```
import csv

def updateHypothesis(x,h):
    if h==[]:
        return x

    for i in range(0,len(h)):
        if x[i].upper()!=h[i].upper():
            h[i] = '?'

    return h

if __name__ == "__main__":
    data = []
    h = []

    # reading csv file
    with open('data.csv', 'r') as file:
        reader = csv.reader(file)
        print("Data: ")
        for row in reader:
            data.append(row)
            print(row)

    if data:
        for x in data:
            if x[-1].upper()=="YES":
                x.pop() # removing last field
```

```
            h = updateHypothesis(x,h)

    print("\nHypothesis: ",h)
```

Output:

```
Data:
['GREEN', 'HARD', 'NO', 'WRINKLED', 'YES']
['GREEN', 'HARD', 'YES', 'SMOOTH', 'NO']
['BROWN', 'SOFT', 'NO', 'WRINKLED', 'NO']
['ORANGE', 'HARD', 'NO', 'WRINKLED', 'YES']
['GREEN', 'SOFT', 'NO', 'WRINKLED', 'YES']

Hypothesis:  ['?', '?', 'NO', 'WRINKLED']
```

2) For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate-Elimination algorithm to output a description of the set of all hypotheses consistent with the training examples.

```
import numpy as np
import pandas as pd

data = pd.DataFrame(data=pd.read_csv('data.csv'))
concepts = np.array(data.iloc[:,0:-1])
print('Concepts:', concepts)
target = np.array(data.iloc[:,-1])
print('Target:', target)

def learn(concepts, target):
    print("Initialization of specific_h and general_h")

    specific_h = concepts[0].copy()
    print('\t specific_h:', specific_h)
```

```
    general_h = [["?" for i in range(len(specific_h))] for i in
range(len(specific_h))]
    print('\t general_h:', general_h)

    for i, h in enumerate(concepts):
        if target[i] == "yes":
            for x in range(len(specific_h)):
                if h[x]!= specific_h[x]:
                    specific_h[x] ='?'
                    general_h[x][x] ='?'
        if target[i] == "no":
            for x in range(len(specific_h)):
                if h[x]!= specific_h[x]:
                    general_h[x][x] = specific_h[x]
                else:
                    general_h[x][x] = '?'

        print("\n Steps of Candidate Elimination Algorithm",i+1)
        print('\t specific_h', specific_h)
        print('\t general_h:', general_h)

    indices = [i for i, val in enumerate(general_h) if val == ['?', '?', '?', '?',
'?', '?']]
    for i in indices:
        general_h.remove(['?', '?', '?', '?', '?', '?'])
    return specific_h, general_h

s_final, g_final = learn(concepts, target)

print("\n Final specific_h:", s_final, sep="\n")
print("\n Final general_h:", g_final, sep="\n")
```

Output:

```
    sky  temp humidity    wind water forcast enjoysport
0  sunny  warm   normal  strong  warm    same       yes
1  sunny  warm     high  strong  warm    same       yes
2  rainy  cold     high  strong  warm  change        no
```

3 sunny warm high strong cool change yes

The attributes are: [['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'high' 'strong' 'warm' 'same']
['rainy' 'cold' 'high' 'strong' 'warm' 'change']
['sunny' 'warm' 'high' 'strong' 'cool' 'change']]

The target is: ['yes' 'yes' 'no' 'yes']

Initialization of specific_h and general_h
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']

Steps of Candidate Elimination Algorithm 1
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' 'normal' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']

Steps of Candidate Elimination Algorithm 2
['sunny' 'warm' '?' 'strong' 'warm' 'same']
[['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]
['sunny' 'warm' '?' 'strong' 'warm' 'same']

Steps of Candidate Elimination Algorithm 3

['sunny' 'warm' '?' 'strong' 'warm' 'same']
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', 'same']]
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' 'warm' 'same']
['sunny' 'warm' '?' 'strong' '?' 'same']
['sunny' 'warm' '?' 'strong' '?' '?']
['sunny' 'warm' '?' 'strong' '?' '?']

Steps of Candidate Elimination Algorithm 4
['sunny' 'warm' '?' 'strong' '?' '?']
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?']]

Final Specific_h:
['sunny' 'warm' '?' 'strong' '?' '?']
Final General_h:
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?']]

3) Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.

```
import math
import csv
def load_csv(filename):
    lines=csv.reader(open(filename,"r"));
    dataset = list(lines)
    headers = dataset.pop(0)
    return dataset,headers

class Node:
    def __init__(self,attribute):
        self.attribute=attribute
        self.children=[]
        self.answer=""

def subtables(data,col,delete):
    dic={}
    coldata=[row[col] for row in data]
    attr=list(set(coldata))

    counts=[0]*len(attr)
    r=len(data)
    c=len(data[0])
    for x in range(len(attr)):
        for y in range(r):
            if data[y][col]==attr[x]:
                counts[x]+=1

    for x in range(len(attr)):
        dic[attr[x]]=[[0 for i in range(c)] for j in range(counts[x])]
        pos=0
        for y in range(r):
            if data[y][col]==attr[x]:
                if delete:
                    del data[y][col]
                dic[attr[x]][pos]=data[y]
                pos+=1
```

```
    return attr,dic

def entropy(S):
    attr=list(set(S))
    if len(attr)==1:
        return 0

    counts=[0,0]
    for i in range(2):
        counts[i]=sum([1 for x in S if attr[i]==x])/(len(S)*1.0)

    sums=0
    for cnt in counts:
        sums+=-1*cnt*math.log(cnt,2)
    return sums

def compute_gain(data,col):
    attr,dic = subtables(data,col,delete=False)

    total_size=len(data)
    entropies=[0]*len(attr)
    ratio=[0]*len(attr)

    total_entropy=entropy([row[-1] for row in data])
    for x in range(len(attr)):
        ratio[x]=len(dic[attr[x]])/(total_size*1.0)
        entropies[x]=entropy([row[-1] for row in dic[attr[x]]])
        total_entropy-=ratio[x]*entropies[x]
    return total_entropy

def build_tree(data,features):
    lastcol=[row[-1] for row in data]
    if(len(set(lastcol)))==1:
        node=Node("")
        node.answer=lastcol[0]
        return node

    n=len(data[0])-1
    gains=[0]*n
    for col in range(n):
```

```
        gains[col]=compute_gain(data,col)
    split=gains.index(max(gains))
    node=Node(features[split])
    fea = features[:split]+features[split+1:]


    attr,dic=subtables(data,split,delete=True)

    for x in range(len(attr)):
        child=build_tree(dic[attr[x]],fea)
        node.children.append((attr[x],child))
    return node

def print_tree(node,level):
    if node.answer!="":
        print("  "*level,node.answer)
        return

    print("  "*level,node.attribute)
    for value,n in node.children:
        print("  "*(level+1),value)
        print_tree(n,level+2)


def classify(node,x_test,features):
    if node.answer!="":
        print(node.answer)
        return
    pos=features.index(node.attribute)
    for value, n in node.children:
        if x_test[pos]==value:
            classify(n,x_test,features)

'''Main program'''
dataset,features=load_csv("id3.csv")
node1=build_tree(dataset,features)

print("The decision tree for the dataset using ID3 algorithm is")
print_tree(node1,0)
testdata,features=load_csv("id3_test.csv")
```

```
for xtest in testdata:
    print("The test instance:",xtest)
    print("The label for test instance:",end="    ")
    classify(node1,xtest,features)
```

Output:

```
The decision tree for the dataset using ID3 algorithm is
 Outlook
   rain
     Wind
       strong
         no
       weak
         yes
   overcast
     yes
   sunny
     Humidity
       high
         no
       normal
         yes
The test instance: ['rain', 'cool', 'normal', 'strong']
The label for test instance:   no
The test instance: ['sunny', 'mild', 'normal', 'strong']
The label for test instance:   yes
```

4) Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.

```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import GaussianNB
from sklearn import metrics

df = pd.read_csv("pima_indian.csv")
feature_col_names = ['num_preg', 'glucose_conc', 'diastolic_bp',
'thickness', 'insulin', 'bmi', 'diab_pred', 'age']
predicted_class_names = ['diabetes']
```

```
X = df[feature_col_names].values # these are factors for the prediction
y = df[predicted_class_names].values # this is what we want to predict

#splitting the dataset into train and test data

xtrain,xtest,ytrain,ytest=train_test_split(X,y,test_size=0.33)

print ('\n the total number of Training Data :',ytrain.shape)
print ('\n the total number of Test Data :',ytest.shape)


# Training Naive Bayes (NB) classifier on training data.

clf = GaussianNB().fit(xtrain,ytrain.ravel())
predicted = clf.predict(xtest)
predictTestData= clf.predict([[6,148,72,35,0,33.6,0.627,50]])

#printing Confusion matrix, accuracy, Precision and Recall

print('\n Confusion matrix')
print(metrics.confusion_matrix(ytest,predicted))

print('\n Accuracy of the classifier
is',metrics.accuracy_score(ytest,predicted))

print('\n The value of Precision', metrics.precision_score(ytest,predicted))

print('\n The value of Recall', metrics.recall_score(ytest,predicted))

print("Predicted Value for individual Test Data:", predictTestData)
```

OUTPUT:

```
<bound method NDFrame.head of      num_preg  glucose_conc  diastolic_bp  thickness  insulin   bmi  \
0           6           148            72         35        0  33.6
1           1            85            66         29        0  26.6
2           8           183            64          0        0  23.3
3           1            89            66         23       94  28.1
4           0           137            40         35      168  43.1
..        ...           ...           ...        ...      ...   ...
140         3           128            78          0        0  21.1
141         5           106            82         30        0  39.5
142         2           108            52         26       63  32.5
143        10           108            66          0        0  32.4
144         4           154            62         31      284  32.8

     diab_pred  age  diabetes
0        0.627   50         1
1        0.351   31         0
2        0.672   32         1
3        0.167   21         0
4        2.288   33         1
..         ...  ...       ...
140      0.268   55         0
141      0.286   38         0
142      0.318   22         0
143      0.272   42         1
144      0.237   23         0

[145 rows x 9 columns]>

 the total number of Training Data : (87, 1)

 the total number of Test Data : (58, 1)

 Confusion matrix
[[28 10]
 [ 8 12]]

 Accuracy of the classifier is 0.6896551724137931

 The value of Precision 0.5454545454545454

 The value of Recall 0.6
Predicted Value for individual Test Data: [1]
```

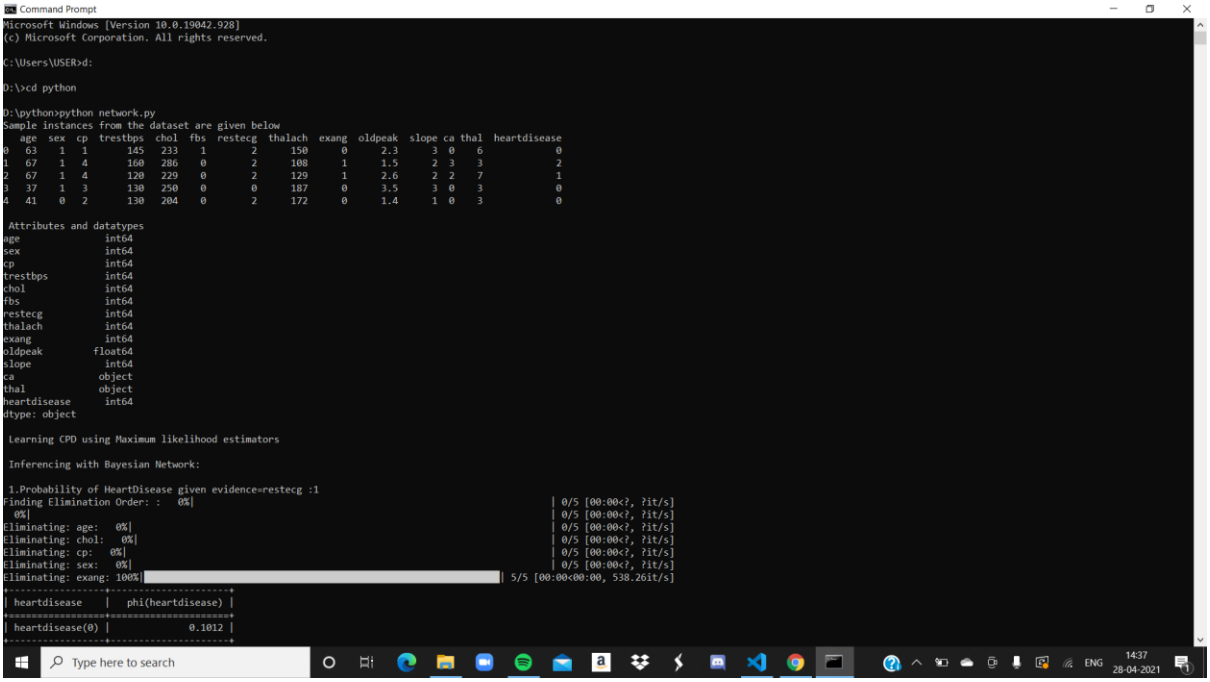
```
 the total number of Training Data : (101, 1)

 the total number of Test Data : (44, 1)

 Confusion matrix
[[23  4]
 [ 6 11]]

 Accuracy of the classifier is 0.7727272727272727

 The value of Precision 0.7333333333333333

 The value of Recall 0.6470588235294118
Predicted Value for individual Test Data: [1]
```

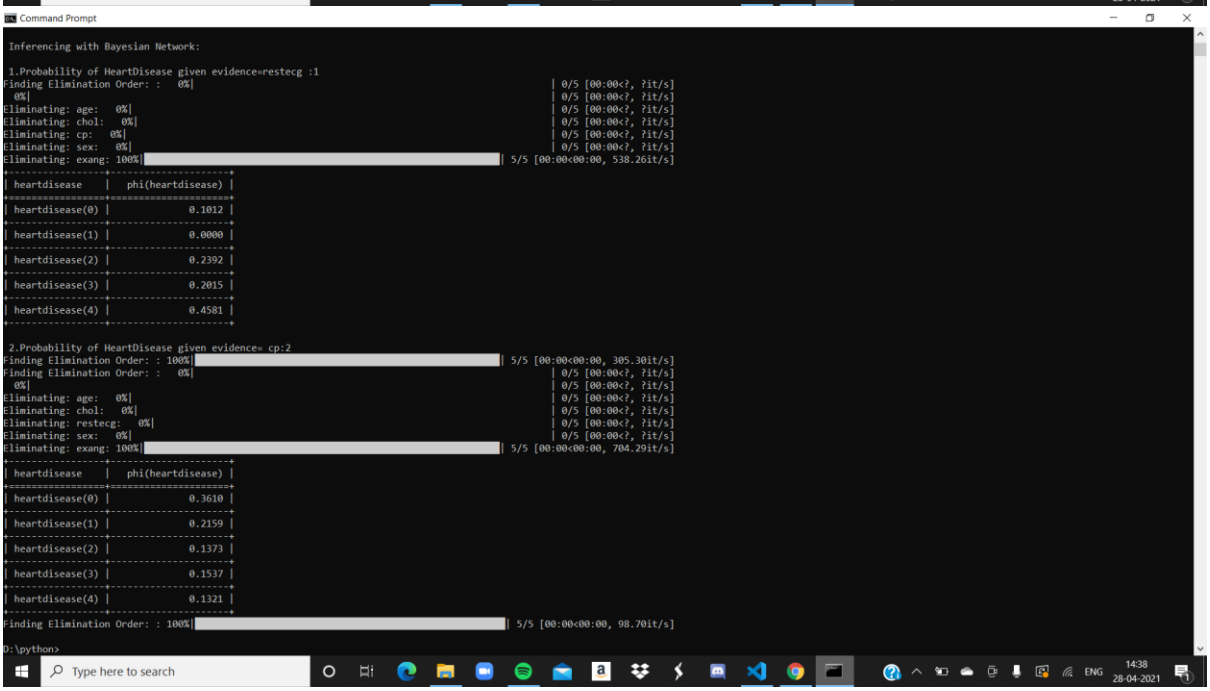
5) i)Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set. You can use Java/Python ML library classes/API.

```
import numpy as np
import pandas as pd
import csv
from pgmpy.estimators import MaximumLikelihoodEstimator
from pgmpy.models import BayesianModel
from pgmpy.inference import VariableElimination

#read Cleveland Heart Disease data
heartDisease = pd.read_csv('heart.csv')
heartDisease = heartDisease.replace('?',np.nan)

#display the data
print('Sample instances from the dataset are given below')
print(heartDisease.head())

#display the Attributes names and datatyes
print('\n Attributes and datatypes')
print(heartDisease.dtypes)

#Create Model- Bayesian Network
model = BayesianModel([('age','heartdisease'),('sex','heartdisease'),(
'exang','heartdisease'),('cp','heartdisease'),('heartdisease',
'restecg'),('heartdisease','chol')])

#Learning CPDs using Maximum Likelihood Estimators
print('\n Learning CPD using Maximum likelihood estimators')
model.fit(heartDisease,estimator=MaximumLikelihoodEstimator)

# Inferencing with Bayesian Network
print('\n Inferencing with Bayesian Network:')
HeartDiseasetest_infer = VariableElimination(model)

#computing the Probability of HeartDisease given restecg
print('\n 1.Probability of HeartDisease given evidence=restecg :1')
```

```
q1=HeartDiseasetest_infer.query(variables=['heartdisease'],evidence={'re
stecg':1})
print(q1)

#computing the Probability of HeartDisease given cp
print('\n 2.Probability of HeartDisease given evidence= cp:2 ')
q2=HeartDiseasetest_infer.query(variables=['heartdisease'],evidence={'cp
':2})
print(q2)
```

OUTPUT:





ii) Bayesian network Example

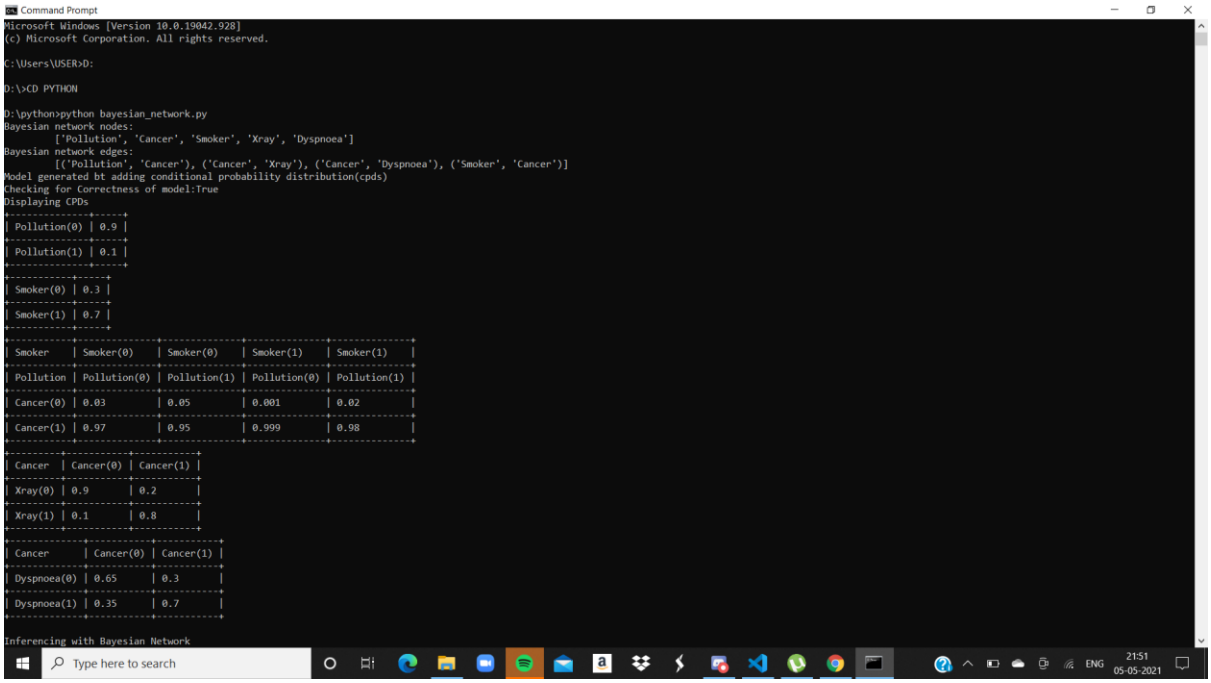
```
from pgmpy.models import BayesianModel
from pgmpy.factors.discrete import TabularCPD
```

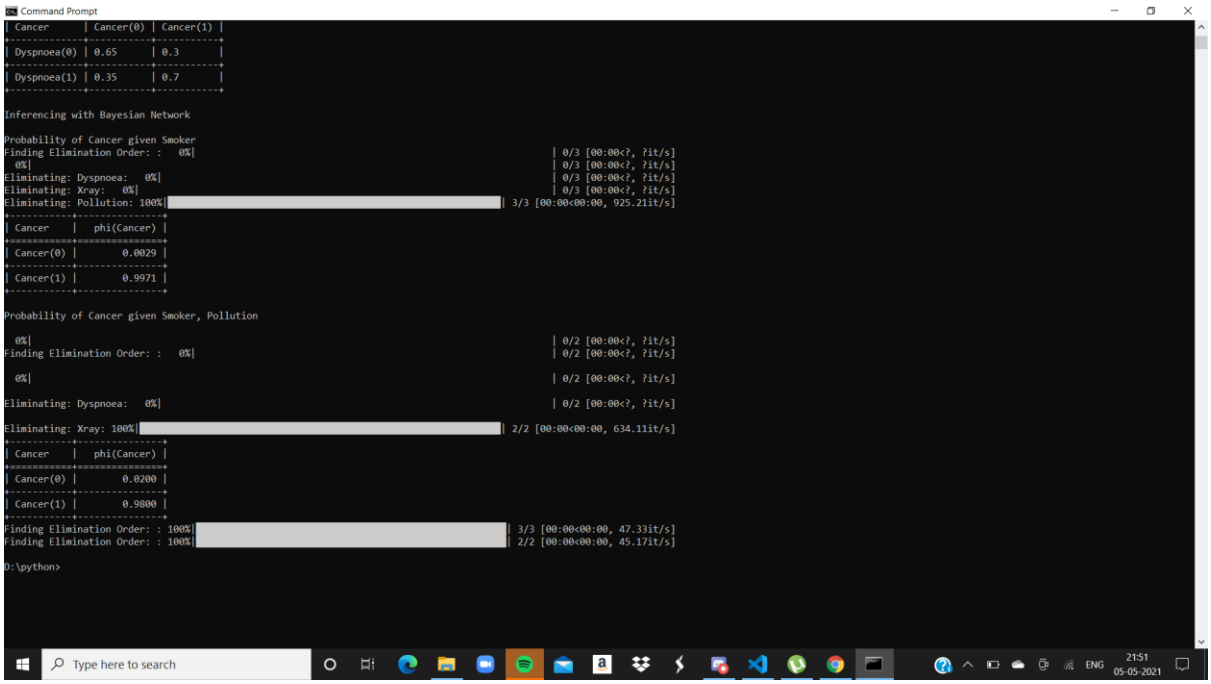
```
from pgmpy.inference import VariableElimination

#Define a Structure with nodes and edges
cancer_model = BayesianModel([('Pollution', 'Cancer'),
                              ('Smoker', 'Cancer'),
                              ('Cancer', 'Xray'),
                              ('Cancer', 'Dyspnoea')])
print('Bayesian network nodes:')
print('\t', cancer_model.nodes())
print('Bayesian network edges:')
print('\t', cancer_model.edges())

#Creation of Conditional Probability Table
cpd_poll = TabularCPD(variable='Pollution', variable_card=2,
                      values=[[0.9], [0.1]])
cpd_smoke = TabularCPD(variable='Smoker', variable_card=2,
                       values=[[0.3], [0.7]])
cpd_cancer = TabularCPD(variable='Cancer', variable_card=2,
                        values=[[0.03, 0.05, 0.001, 0.02],
                                [0.97, 0.95, 0.999, 0.98]],
                        evidence=['Smoker', 'Pollution'],
                        evidence_card=[2, 2])
cpd_xray = TabularCPD(variable='Xray', variable_card=2,
                      values=[[0.9, 0.2], [0.1, 0.8]],
                      evidence=['Cancer'], evidence_card=[2])
cpd_dysp = TabularCPD(variable='Dyspnoea', variable_card=2,
                      values=[[0.65, 0.3], [0.35, 0.7]],
```

```
                    evidence=['Cancer'], evidence_card=[2])

# Associating the parameters with the model structure.
cancer_model.add_cpds(cpd_poll, cpd_smoke, cpd_cancer, cpd_xray,
cpd_dysp)
print('Model generated bt adding conditional probability distribution(cpds)')

# Checking if the cpds are valid for the model.
print('Checking for Correctness of model:', end='')
print(cancer_model.check_model())



'''print('All local dependencies are as follows')
cancer_model.get_independencies()
'''

print('Displaying CPDs')
print(cancer_model.get_cpds('Pollution'))
print(cancer_model.get_cpds('Smoker'))
print(cancer_model.get_cpds('Cancer'))
print(cancer_model.get_cpds('Xray'))
print(cancer_model.get_cpds('Dyspnoea'))

#Inferencing with Bayesian Network
#Computing the probability of Cancer given smoke

cancer_infer = VariableElimination(cancer_model)
print('\nInferencing with Bayesian Network')
```

```
print('\nProbability of Cancer given Smoker')
q = cancer_infer.query(variables=['Cancer'], evidence={'Smoker': 1})
print(q)

print('\nProbability of Cancer given Smoker, Pollution')
q = cancer_infer.query(variables=['Cancer'], evidence={'Smoker': 1,'Pollution': 1})
print(q)
```

OUTPUT:


Command Prompt
Microsoft Windows [Version 10.0.19042.928]
(c) Microsoft Corporation. All rights reserved.
C:\Users\USER>D:
D:\>CD PYTHON
D:\python>python bayesian_network.py
Bayesian network nodes:
['Pollution', 'Cancer', 'Smoker', 'Xray', 'Dyspnoea']
Bayesian network edges:
[('Pollution', 'Cancer'), ('Cancer', 'Xray'), ('Cancer', 'Dyspnoea'), ('Smoker', 'Cancer')]
Model generated bt adding conditional probability distribution(cpds)
Checking for Correctness of model:True
Displaying CPDs
Pollution(0)	0.9
Pollution(1)	0.1
Smoker(0)	0.3
Smoker(1)	0.7
Smoker	Smoker(0)	Smoker(0)	Smoker(1)	Smoker(1)
Pollution	Pollution(0)	Pollution(1)	Pollution(0)	Pollution(1)
Cancer(0)	0.03	0.05	0.001	0.02
Cancer(1)	0.97	0.95	0.999	0.98
Cancer	Cancer(0)	Cancer(1)
Xray(0)	0.9	0.2
Xray(1)	0.1	0.8
Cancer	Cancer(0)	Cancer(1)
Dyspnoea(0)	0.65	0.3
Dyspnoea(1)	0.35	0.7
Inferencing with Bayesian Network
Type here to search
ENG
21:51
05-05-2021


Command Prompt
Cancer	Cancer(0)	Cancer(1)
Dyspnoea(0)	0.65	0.3
Dyspnoea(1)	0.35	0.7
Inferencing with Bayesian Network
Probability of Cancer given Smoker
Finding Elimination Order: : 0%		0/3 [00:00<?, ?it/s]
0%		0/3 [00:00<?, ?it/s]
Eliminating: Dyspnoea: 0%		0/3 [00:00<?, ?it/s]
Eliminating: Xray: 0%		0/3 [00:00<?, ?it/s]
Eliminating: Pollution: 100%| 3/3 [00:00<00:00, 925.21it/s]
Cancer	phi(Cancer)
Cancer(0)	0.0029
Cancer(1)	0.9971
Probability of Cancer given Smoker, Pollution
0%		0/2 [00:00<?, ?it/s]
Finding Elimination Order: : 0%		0/2 [00:00<?, ?it/s]
0%		0/2 [00:00<?, ?it/s]
Eliminating: Dyspnoea: 0%		0/2 [00:00<?, ?it/s]
Eliminating: Xray: 100%| 2/2 [00:00<00:00, 634.11it/s]
Cancer	phi(Cancer)
Cancer(0)	0.0200
Cancer(1)	0.9800
Finding Elimination Order: : 100%| 3/3 [00:00<00:00, 47.33it/s]
Finding Elimination Order: : 100%| 2/2 [00:00<00:00, 45.17it/s]
D:\python>
Type here to search
ENG
21:51
05-05-2021