ML LAB REPORT

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1BM18CS082

Week 1:

i)Find s algorithm

```
# This Python 3 environment comes with many helpful analytics libraries ins
talled
# It is defined by the kaggle/python Docker image: https://github.com/kaggl
e/docker-python
# For example, here's several helpful packages to load
 import numpy as np # linear algebra import pandas as pd # data
processing, CSV file I/O (e.g. pd.read_csv)

# Input data files are available in the read-only "../input/" directory #
For example, running this (by clicking run or pressing Shift+Enter) will
list all files under the input directory
 import os for dirname, _, filenames in
os.walk('/kaggle/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))

# You can write up to 20GB to the current directory (/kaggle/working/) that
gets preserved as output when you create a version using "Save & Run All"
# You can also write temporary files to /kaggle/temp/, but they won't be sa
ved outside of the current session
```

```
/kaggle/input/datasetcsv/data.csv
```

```
data =
pd.read_csv("/kaggle/input/datasetcsv/data.csv")
print("The entered data is \n") print(data,"\n") d =
np.array(data)[:,:-1]
print("\n The attributes are:
\n",d) target = np.array(data)[:,-
1] print("\n The target is:
",target) def training(c,t):
for i, val in enumerate(t):
if val == "Yes":
            specific_hypothesis = c[i].copy()
break
```

```
    for i, val in enumerate(c):         if t[i] ==
"Yes":             for x in
range(len(specific_hypothesis)):In                 if
val[x] != specific_hypothesis[x]:
                    specific_hypothesis[x] = '?'
else:                    pass     return
specific_hypothesis
print("\n The final hypothesis is:",training(d,target))
```

Output:

```
The entered data is

  Weather Temperature Humidity Goes
0   Sunny        Warm      Mild  Yes
1   Rainy        Cold     Mild   No
2   Sunny     Moderate    Nomal  Yes
3   Sunny         Cold    High   Yes


 The attributes are:
 [['Sunny ' 'Warm ' 'Mild']
 ['Rainy' 'Cold' 'Mild']
 ['Sunny ' 'Moderate' 'Nomal']
 ['Sunny ' 'Cold' 'High ']]

 The target is:  ['Yes' 'No' 'Yes' 'Yes']

 The final hypothesis is: ['Sunny ' '?' '?']
```

Week 2:

ii)Candidate elimination algorithm:

```
# This Python 3 environment comes with many helpful analytics libraries ins
talled
# It is defined by the kaggle/python Docker image: https://github.com/kaggl
e/docker-python
# For example, here's several helpful packages to load

import numpy as np # linear algebra import pandas as pd # data
processing, CSV file I/O (e.g. pd.read_csv)

# Input data files are available in the read-only "../input/" directory #
For example, running this (by clicking run or pressing Shift+Enter) will
list all files under the input directory
```

```
 import
os for
dirname,
_,
filenames
in
os.walk('
/kaggle/i
nput'):
for
filename
in
filenames
:
        print(os.path.join(dirname, filename))

# You can write up to 20GB to the current directory (/kaggle/working/) that
gets preserved as output when you create a version using "Save & Run All"
# You can also write temporary files to /kaggle/temp/, but they won't be sa
ved outside of the current session /kaggle/input/candidatecsv/candidate.csv
 data =
pd.read_csv("/kaggle/input/candidatecsv/candidate.csv")
print("Entered data is") print(data) concepts =
np.array(data)[:,:-1] print("\n The attributes are: \n",d)
target = np.array(data)[:,-1] print("\n The target is:
",target)

Entered data is      sky airtemp humidity     wind water
forecast 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']
```

```
#training function to implement candidate_elimination algorithm def
learn(concepts, target):
 specific_h = concepts[0].copy()
 print("\n Initialization of specific_h and general_h")
print(specific_h)
 general_h = [["?" for i in range(len(specific_h))] for i in
range(len(specific_h))]  print(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] ='?'
print(specific_h)      print(specific_h)
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(specific_h)      print(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)

#obtaining the final hypothesis
print("\nFinal    Specific_h:",    s_final,    sep="\n")
print("\nFinal General_h:", g_final, sep="\n")
```

Output:

```
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' '?' '?' 'warm' 'same']
['sunny' 'warm' '?' '?' 'warm' 'same']
['sunny' 'warm' '?' '?' 'warm' 'same']
['sunny' 'warm' '?' '?' 'warm' 'same']


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

 Steps of Candidate Elimination Algorithm 3
['sunny' 'warm' '?' '?' 'warm' 'same']
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?'],
['?', '?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', '?'], ['?', '
?', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', 'same']]
['sunny' 'warm' '?' '?' 'warm' 'same']
['sunny' 'warm' '?' '?' 'warm' 'same']
['sunny' 'warm' '?' '?' 'warm' 'same']
['sunny' 'warm' '?' '?' 'warm' 'same']
['sunny' 'warm' '?' '?' '?' 'same']
['sunny' 'warm' '?' '?' '?' '?']
['sunny' 'warm' '?' '?' '?' '?']

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

Final Specific_h:
['sunny' 'warm' '?' '?' '?' '?']

Final General_h:
[['sunny', '?', '?', '?', '?', '?'], ['?', 'warm', '?', '?', '?', '?']]
```

Week 3:

ID3 algorithm:

```
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


                                attr=list(set(coldata))
               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)
```

```
          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:")
classify(node1,xtest,features)
```

Output:

```
bmsce@bmsce-Precision-T1700:~/Documents/LAB - 3 - DECISION TREE$ python ml3.py
The decision tree for the dataset using ID3 algorithm is
('', 'Outlook')
('   ', 'overcast')
('     ', 'yes')
('   ', 'sunny')
('     ', 'Humidity')
('       ', 'high')
('         ', 'no')
('       ', 'normal')
('         ', 'yes')
('   ', 'rain')
('     ', 'Wind')
('       ', 'strong')
('         ', 'no')
('       ', 'weak')
('         ', '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
```

Week 4:

iv)Naïve bayes classifier:

```
import pandas as pd

data = pd.read_csv('PlayTennis.csv') data.head()

y = list(data['PlayTennis'].values) X

= data.iloc[:,1:].values

print(f'Target Values: {y}')

print(f'Features: \n{X}')
```

```
Target Values: ['No', 'No', 'Yes', 'Yes', 'Yes', 'No', 'Yes', 'No', 'Yes',
'Yes', 'Yes', 'Yes', 'Yes', 'No'] Features:
[['Sunny' 'Hot' 'High' 'Weak']
 ['Sunny' 'Hot' 'High' 'Strong']
 ['Overcast' 'Hot' 'High' 'Weak']
 ['Rain' 'Mild' 'High' 'Weak']
 ['Rain' 'Cool' 'Normal' 'Weak']
 ['Rain' 'Cool' 'Normal' 'Strong']
 ['Overcast' 'Cool' 'Normal' 'Strong']
 ['Sunny' 'Mild' 'High' 'Weak']
 ['Sunny' 'Cool' 'Normal' 'Weak']
 ['Rain' 'Mild' 'Normal' 'Weak']
 ['Sunny' 'Mild' 'Normal' 'Strong']
['Overcast' 'Mild' 'High' 'Strong']
 ['Overcast' 'Hot' 'Normal' 'Weak']
 ['Rain' 'Mild' 'High' 'Strong']]
```

```
y train = y[:8]


X train = X[:8]
X val = X[8:]

print(f"Number of instances in training set: {len(X train)}")
print(f"Number of instances in testing set: {len(X val)}")
```

```
Number of instances in training set: 8
Number of instances in testing set: 6
```

```
class NaiveBayesClassifier:
y_val = y[8:]
```

```
            def __init__(self, X, y):
```

```
        self.X, self.y = X, y

        self.N = len(self.X)
```

```
        self.dim = len(self.X[0])

        self.attrs = [[] for _ in range(self.dim)]

        self.output_dom = {}

        self.data = []
                for i in range(len(self.X)):
for j in range(self.dim):                   if not
self.X[i][j] in self.attrs[j]:
self.attrs[j].append(self.X[i][j])
                                    if not self.y[i] in
self.output_dom.keys():
                self.output_dom[self.y[i]] = 1

else:
                self.output_dom[self.y[i]] += 1

            self.data.append([self.X[i], self.y[i]])
def classify(self, entry):
         solve =
None
max_arg = -1
         for y in
self.output_dom.keys():

            prob = self.output_dom[y]/self.N
             for i in
range(self.dim):
                cases = [x for x in self.data if x[0][i] == entry[i]
an d x[1] == y]
                n = len(cases)
prob *= n/self.N

if prob > max_arg:
max_arg = prob
solve = y

        return solve

nbc = NaiveBayesClassifier(X_train, y_train)

total_cases = len(y_val)
 good =
0 bad =
0
predictions = []
 for i in
range(total_cases):
    predict = nbc.classify(X_val[i])
predictions.append(predict)
     if y_val[i] ==
predict:
```

```
        good += 1
else:           bad
+= 1
```

```
print('Predicted values:', predictions) print('Actual values:', y_val)
print() print('Total number of testing instances in the dataset:',
total_cases) print('Number of correct predictions:', good)
print('Number of wrong predictions:', bad) print()
print('Accuracy of Bayes Classifier:', good/total_cases)
```

Output:

```
Predicted values: ['No', 'Yes', 'No', 'Yes', 'Yes', 'No']
Actual values: ['Yes', 'Yes', 'Yes', 'Yes', 'Yes', 'No']

Total number of testing instances in the dataset: 6
Number of correct predictions: 4
Number of wrong predictions: 2

Accuracy of Bayes Classifier: 0.6666666666666666
```

Week 5:

v)Bayesian network:

```
# This Python 3 environment comes with many helpful analytics libraries installed  # It is defined by the kaggle/python Docker image: https://github.com/kaggle/docker-python  # For example, here's several helpful packages to load  import numpy as np

# linear algebra

import pandas as pd  import pgmpy as pgmpy from pgmpy.estimators

import MaximumLikelihoodEstimator from pgmpy.models  import

BayesianModel from pgmpy.inference  import VariableElimination

import os for dirname, _, filenames in os.walk('/kaggle/input'):

for filename in filenames: print(os.path.join(dirname, filename))  # You can write up to 20GB to the current directory (/kaggle/working/) that gets preserved as output when you create a version using "Save & Run All" # You can also write temporary files to /kaggle/temp/, but they won't be saved outside of the current session
```

```
#read Cleveland Heart Disease data
heartDisease = pd.read_csv("/kaggle/input/bayesiannetwork/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)
#Creat 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={'r
estecg':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={'c
p':2}) print(q2)
```

Output:

```
Sample instances from the dataset are given below
   age  sex  cp  trestbps  chol  fbs  restecg  thalach  exang  oldpeak
slope  \
0   63    1   1       145   233    1        2      150      0      2.3
    3
1   67    1   4       160   286    0        2      108      1      1.5
    2
2   67    1   4       120   229    0        2      129      1      2.6
2
3   37    1   3       130   250    0        0      187      0      3.5
3
4   41    0   2       130   204    0        2      172      0      1.4
1       ca thal
heartdisease   0  0
6              0
1  3    3             2
2  2    7             1
3  0    3             0
4  0    3             0

 Attributes and datatypes
age               int64
sex               int64 cp
int64 trestbps
int64 chol
int64 fbs
int64 restecg
int64 thalach
```

```
int64 exang
int64 oldpeak
float64 slope
int64 ca
object thal
object heartdisease
int64 dtype: object

 Learning CPD using Maximum likelihood estimators
Finding Elimination Order: :   0%|          | 0/5 [00:00<?, ?it/s]
  0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: age:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: chol:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: cp:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: sex:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: exang: 100%|██████████| 5/5 [00:00<00:00, 189.65it/s]
Finding Elimination Order: : 100%|██████████| 5/5 [00:00<00:00, 132.81it/s]
Finding Elimination Order: :   0%|          | 0/5 [00:00<?, ?it/s]
  0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: age:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: chol:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: restecg:   0%|          | 0/5 [00:00<?, ?it/s]
Eliminating: sex:   0%|          | 0/5 [00:00<?, ?it/s]     Eliminating:
exang: 100%|██████████| 5/5 [00:00<00:00, 230.00it/s]
 Inferencing with Bayesian Network:
1.Probability of HeartDisease given evidence= restecg :1
+-----------------+---------------------+
| heartdisease    |   phi(heartdisease) |
+=================+=====================+
| heartdisease(0) |              0.1012 |
+-----------------+---------------------+
| heartdisease(1) |              0.0000 |
+-----------------+---------------------+
| heartdisease(2) |              0.2392 |
+-----------------+---------------------+
| heartdisease(3) |              0.2015 |
+-----------------+---------------------+
| heartdisease(4) |              0.4581 |
+-----------------+---------------------+

 2.Probability of HeartDisease given evidence= cp:2
+-----------------+---------------------+
| heartdisease    |   phi(heartdisease) |
+=================+=====================+
| heartdisease(0) |              0.3610 |
+-----------------+---------------------+
| heartdisease(1) |              0.2159 |
+-----------------+---------------------+
| heartdisease(2) |              0.1373 |
+-----------------+---------------------+
| heartdisease(3) |              0.1537 |
+-----------------+---------------------+
```

```
| heartdisease(4) |              0.1321  +-----------------+---------------
-----+
```

WEEK 6: vi)Inferring from Bayesian model:

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

```
cancer_model = BayesianModel([('Pollution','Cancer'),
                              ('Smoker','Cancer'),
                              ('Cancer','Xray'),
('Cancer','Dyspnoea')]) print('Bayesian network
nodes are:') print("\t",cancer_model.nodes())
print('Bayesian network edges are:')
print("\t",cancer_model.edges())

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])
```

```
Bayesian network nodes are:
       ['Pollution', 'Cancer', 'Smoker', 'Xray', 'Dyspnoea'] Bayesian
network edges are:
  [('Pollution', 'Cancer'), ('Cancer', 'Xray'), ('Cancer', 'Dyspn oea'),
('Smoker', 'Cancer')]
```

```
cancer_model.add_cpds(cpd_poll,cpd_smoke,cpd_cancer,cpd_xray,cpd_dysp)
print('Model generated by adding cpts(cpds)') print('Checking
correctness of model:',end='') print(cancer_model.check_model())
```

```
Model generated by adding cpts(cpds)
Checking correctness of model:True
```

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

```
All local depencies are as follows
```

Out[10]:

```
(Pollution ⊥ Smoker)
(Pollution ⊥ Dyspnoea, Xray | Cancer)
(Pollution ⊥ Xray | Dyspnoea, Cancer)
(Pollution ⊥ Dyspnoea | Cancer, Xray)
(Pollution ⊥ Dyspnoea, Xray | Cancer, Smoker)
(Pollution ⊥ Xray | Dyspnoea, Cancer, Smoker)
(Pollution ⊥ Dyspnoea | Cancer, Xray, Smoker)
(Smoker ⊥ Pollution)
(Smoker ⊥ Dyspnoea, Xray | Cancer)
(Smoker ⊥ Xray | Dyspnoea, Cancer)
(Smoker ⊥ Dyspnoea, Xray | Pollution, Cancer)
(Smoker ⊥ Dyspnoea | Cancer, Xray)
(Smoker ⊥ Xray | Dyspnoea, Pollution, Cancer)
(Smoker ⊥ Dyspnoea | Pollution, Cancer, Xray)
(Xray ⊥ Dyspnoea, Pollution, Smoker | Cancer)
(Xray ⊥ Pollution, Smoker | Dyspnoea, Cancer)
(Xray ⊥ Dyspnoea, Smoker | Pollution, Cancer)
(Xray ⊥ Dyspnoea, Pollution | Cancer, Smoker)
(Xray ⊥ Smoker | Dyspnoea, Pollution, Cancer)
(Xray ⊥ Pollution | Dyspnoea, Cancer, Smoker)
(Xray ⊥ Dyspnoea | Pollution, Cancer, Smoker)
(Dyspnoea ⊥ Pollution, Xray, Smoker | Cancer)
(Dyspnoea ⊥ Xray, Smoker | Pollution, Cancer)
(Dyspnoea ⊥ Pollution, Smoker | Cancer, Xray)
(Dyspnoea ⊥ Pollution, Xray | Cancer, Smoker)
(Dyspnoea ⊥ Smoker | Pollution, Cancer, Xray)
(Dyspnoea ⊥ Xray | Pollution, Cancer, Smoker)
(Dyspnoea ⊥ Pollution | Cancer, Xray, Smoker) 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'))
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       |
+-------------+-----------+-----------+
```

```
cancer_infer=VariableElimination(cancer_model)
print('\n Inferencing with bayesian network') print("\n
Probability of Cancer given smoker")
q=cancer_infer.query(variables=['Cancer'],evidence={'Smoker':1})
print(q)

print("\n Probability of Cancer given smoker,pollution")
q=cancer_infer.query(variables=['Cancer'],evidence={'Smoker':1,'Polluti
on':1}) print(q)
```

Output:

```
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: Pollution:   0%|          | 0/3 [00:00<?, ?it/s]
Eliminating: Xray: 100%|██████████| 3/3 [00:00<00:00, 359.52it/s]

  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, 333.49it/s]A
 Inferencing with bayesian network

 Probability of Cancer given smoker
+-----------+---------------+
| Cancer    |   phi(Cancer) |
+===========+===============+
| Cancer(0) |        0.0029 |
+-----------+---------------+
| Cancer(1) |        0.9971 |
+-----------+---------------+
Probability of Cancer given smoker,pollution
+-----------+---------------+
| Cancer    |   phi(Cancer) |
+===========+===============+
| Cancer(0) |        0.0200 |
+-----------+---------------+
| Cancer(1) |        0.9800 |
+-----------+---------------+
```