| Ex No. 12 | Construction of Bayesian Belief Network |
|---|---|
| Date: | |

**Aim**

To construct a Bayesian belief network on heart disease data set to predict whether a patient is affected by heart disease based on maximum likelihood estimation.

**Data set**

heart.csv (https://github.com/kb22/Heart-Disease-Prediction/blob/master/dataset.csv)

**Definition**

**Bayesian Belief Network**

**Bayesian Belief Network** is a graphical representation of different probabilistic relationships among random variables in a particular set. It is a classifier with no dependency on attributes i.e it is condition independent. Due to its feature of joint probability, the probability in Bayesian Belief Network is derived, based on a condition — P(attribute/parent) i.e probability of an attribute, true over parent attribute.

**Procedure**

Open PyCharm Community Edition.

Go to File menu → New Project → Specify the project name → Press “Create” button.

Right Click on Project name → New → Python File → Specify the file name → Press Enter.

Type the following codes. Right click on file name or coding window → Select “Run” to view the result.

**BBN.py**

```
import numpy as np
import pandas as pd
from pgmpy.estimators import MaximumLikelihoodEstimator
from pgmpy.models import BayesianNetwork

#read Heart Disease data
data = pd.read_csv("C:/Users/lab4/Downloads/heart.csv")
data = data.replace('?',np.nan)

#display the data
print('Few examples from the dataset are given below')
print(data.head())

print('\n Attributes and datatypes')
print(data.dtypes)

#Model Bayesian Belief Network
model = BayesianNetwork([('age', 'target'), ('sex', 'target'),('cp', 'target'),('trestbps', 'target'),('chol',
'target'),('fbs', 'target'),('restecg', 'target'),('thalach', 'target'),('exang', 'target'),('oldpeak', 'target'),('slope',
'target'),('ca', 'target'),('thal', 'target')])

#Learning CPDs using Maximum Likelihood Estimators
cpd_restecg = MaximumLikelihoodEstimator(model, data).estimate_cpd('restecg')
print(cpd_restecg)

cpd_cp = MaximumLikelihoodEstimator(model, data).estimate_cpd('cp')
print(cpd_cp)

cpd_oldpeak = MaximumLikelihoodEstimator(model, data).estimate_cpd('oldpeak')
print(cpd_oldpeak)

cpd_exang = MaximumLikelihoodEstimator(model, data).estimate_cpd('exang')
print(cpd_exang)

cpd_age = MaximumLikelihoodEstimator(model, data).estimate_cpd('age')
print(cpd_age)

cpd_chol = MaximumLikelihoodEstimator(model, data).estimate_cpd('chol')
print(cpd_chol)
```

**Output**

```
C:\Users\lab4\PycharmProjects\bnn\venv\Scripts\python.exe C:/Users/lab4/PycharmProjects/bnn/bbn.py
Few examples from the dataset are given below
   age  sex  cp  trestbps  chol  fbs  ...  exang  oldpeak  slope  ca  thal  target
0   63    1   3       145   233    1  ...      0      2.3      0   0     1       1
1   37    1   2       130   250    0  ...      0      3.5      0   0     2       1
2   41    0   1       130   204    0  ...      0      1.4      2   0     2       1
3   56    1   1       120   236    0  ...      0      0.8      2   0     2       1
4   57    0   0       120   354    0  ...      1      0.6      2   0     2       1
[5 rows x 14 columns]
 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            int64
thal          int64
target        int64
dtype: object
```

```
+------------+-----------+
| restecg(0) | 0.485149  |
+------------+-----------+
| restecg(1) | 0.50165   |
+------------+-----------+
| restecg(2) | 0.0132013 |
+------------+-----------+
+-------+-----------+
| cp(0) | 0.471947  |
+-------+-----------+
| cp(1) | 0.165017  |
+-------+-----------+
| cp(2) | 0.287129  |
+-------+-----------+
| cp(3) | 0.0759076 |
+-------+-----------+
```

```
+--------------+------------+
| oldpeak(0.0) | 0.326733   |
+--------------+------------+
| oldpeak(0.1) | 0.0231023  |
+--------------+------------+
| oldpeak(0.2) | 0.039604   |
+--------------+------------+
| oldpeak(0.3) | 0.00990099 |
+--------------+------------+
| oldpeak(0.4) | 0.029703   |
+--------------+------------+
| oldpeak(0.5) | 0.0165017  |
+--------------+------------+
| oldpeak(0.6) | 0.0462046  |
+--------------+------------+
| oldpeak(0.7) | 0.00330033 |
```

| | |
|---|---|
| oldpeak(0.8) | 0.0429043 |
| oldpeak(0.9) | 0.00990099 |
| oldpeak(1.0) | 0.0462046 |
| oldpeak(1.1) | 0.00660066 |
| oldpeak(1.2) | 0.0561056 |
| oldpeak(1.3) | 0.00330033 |
| oldpeak(1.4) | 0.0429043 |
| oldpeak(1.5) | 0.0165017 |
| oldpeak(1.6) | 0.0363036 |
| oldpeak(1.8) | 0.0330033 |
| oldpeak(1.9) | 0.0165017 |
| oldpeak(2.0) | 0.029703 |
| oldpeak(2.1) | 0.00330033 |
| oldpeak(2.2) | 0.0132013 |
| oldpeak(2.3) | 0.00660066 |
| oldpeak(2.4) | 0.00990099 |
| oldpeak(2.5) | 0.00660066 |
| oldpeak(2.6) | 0.019802 |
| oldpeak(2.8) | 0.019802 |
| oldpeak(2.9) | 0.00330033 |
| oldpeak(3.0) | 0.0165017 |
| oldpeak(3.1) | 0.00330033 |
| oldpeak(3.2) | 0.00660066 |
| oldpeak(3.4) | 0.00990099 |
| oldpeak(3.5) | 0.00330033 |
| oldpeak(3.6) | 0.0132013 |
| oldpeak(3.8) | 0.00330033 |
| oldpeak(4.0) | 0.00990099 |
| oldpeak(4.2) | 0.00660066 |
| oldpeak(4.4) | 0.00330033 |
| oldpeak(5.6) | 0.00330033 |
| oldpeak(6.2) | 0.00330033 |

| | |
|---|---|
| exang(0) | 0.673267 |
| exang(1) | 0.326733 |

| | |
|---|---|
| age(29) | 0.00330033 |
| age(34) | 0.00660066 |
| age(35) | 0.0132013 |
| age(37) | 0.00660066 |

```
+---------+------------+
| age(38) | 0.00990099 |
+---------+------------+
| age(39) | 0.0132013  |
+---------+------------+
| age(40) | 0.00990099 |
+---------+------------+
| age(41) | 0.0330033  |
+---------+------------+
| age(42) | 0.0264026  |
+---------+------------+
| age(43) | 0.0264026  |
+---------+------------+
| age(44) | 0.0363036  |
+---------+------------+
| age(45) | 0.0264026  |
+---------+------------+
| age(46) | 0.0231023  |
+---------+------------+
| age(47) | 0.0165017  |
+---------+------------+
| age(48) | 0.0231023  |
+---------+------------+
| age(49) | 0.0165017  |
+---------+------------+
| age(50) | 0.0231023  |
+---------+------------+
| age(51) | 0.039604   |
+---------+------------+
| age(52) | 0.0429043  |
+---------+------------+
| age(53) | 0.0264026  |
+---------+------------+
| age(54) | 0.0528053  |
+---------+------------+
| age(55) | 0.0264026  |
+---------+------------+
| age(56) | 0.0363036  |
+---------+------------+
| age(57) | 0.0561056  |
+---------+------------+
| age(58) | 0.0627063  |
+---------+------------+
| age(59) | 0.0462046  |
+---------+------------+
| age(60) | 0.0363036  |
+---------+------------+
| age(61) | 0.0264026  |
+---------+------------+
| age(62) | 0.0363036  |
+---------+------------+
| age(63) | 0.029703   |
+---------+------------+
| age(64) | 0.0330033  |
+---------+------------+
| age(65) | 0.0264026  |
+---------+------------+
| age(66) | 0.0231023  |
+---------+------------+
| age(67) | 0.029703   |
+---------+------------+
| age(68) | 0.0132013  |
+---------+------------+
| age(69) | 0.00990099 |
+---------+------------+
| age(70) | 0.0132013  |
+---------+------------+
| age(71) | 0.00990099 |
+---------+------------+
| age(74) | 0.00330033 |
+---------+------------+
| age(76) | 0.00330033 |
+---------+------------+
| age(77) | 0.00330033 |
+---------+------------+

Process finished with exit code 0
```

**Result**

Thus, a Bayesian belief network has been successfully constructed on heart disease data set to predict the heart disease based on maximum likelihood estimation.