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ML - Experiment 9 - Bayesian Network

CODE

```
pip install pgmpy

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

# Define the structure of the Bayesian network
model = BayesianModel([('Earthquake', 'Alarm'), ('Burglary', 'Alarm'), ('Alarm',
'JohnCalls'), ('Alarm', 'MaryCalls')])

# Define the conditional probability distributions (CPDs)
cpd_earthquake = TabularCPD(variable='Earthquake', variable_card=2,
values=[[0.99], [0.01]])
cpd_burglary = TabularCPD(variable='Burglary', variable_card=2, values=[[0.99],
[0.01]])
cpd_alarm = TabularCPD(variable='Alarm', variable_card=2, values=[[0.999, 0.71,
0.06, 0.05], [0.001, 0.29, 0.94, 0.95]],
                       evidence=['Earthquake', 'Burglary'], evidence_card=[2, 2])
cpd_john_calls = TabularCPD(variable='JohnCalls', variable_card=2, values=[[0.95,
0.1], [0.05, 0.9]], evidence=['Alarm'], evidence_card=[2])
cpd_mary_calls = TabularCPD(variable='MaryCalls', variable_card=2, values=[[0.99,
0.3], [0.01, 0.7]], evidence=['Alarm'], evidence_card=[2])

# Add CPDs to the model
model.add_cpds(cpd_earthquake, cpd_burglary, cpd_alarm, cpd_john_calls,
cpd_mary_calls)

model.check_model()

inference = VariableElimination(model)

# Query: P(Alarm = True | Earthquake = True, Burglary = True)
result = inference.query(variables=['Alarm'], evidence={'Earthquake': 1, 'Burglary': 1})
print(result)
```

```
# Query: P(JohnCalls = True, MaryCalls = True | Earthquake = True, Burglary = True)
result = inference.query(variables=['JohnCalls', 'MaryCalls'], evidence={'Earthquake': 1, 'Burglary': 1})
print(result)
```

```
+----------+--------------+
| Alarm    |   phi(Alarm) |
+==========+==============+
| Alarm(0) |       0.0500 |
+----------+--------------+
| Alarm(1) |       0.9500 |
+----------+--------------+
+--------------+--------------+----------------------------+
| JohnCalls    | MaryCalls    |   phi(JohnCalls,MaryCalls) |
+==============+==============+============================+
| JohnCalls(0) | MaryCalls(0) |                     0.0755 |
+--------------+--------------+----------------------------+
| JohnCalls(0) | MaryCalls(1) |                     0.0670 |
+--------------+--------------+----------------------------+
| JohnCalls(1) | MaryCalls(0) |                     0.2590 |
+--------------+--------------+----------------------------+
| JohnCalls(1) | MaryCalls(1) |                     0.5985 |
+--------------+--------------+----------------------------+
```

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

# Define the Bayesian Network structure
model = BayesianModel([('Burglary', 'Alarm'), ('Earthquake', 'Alarm'),
                       ('Alarm', 'JohnCalls'), ('Alarm', 'MaryCalls')])

# Define the Conditional Probability Tables (CPTs)
cpd_burglary = TabularCPD(variable='Burglary', variable_card=2, values=[[0.999], [0.001]])
cpd_earthquake = TabularCPD(variable='Earthquake', variable_card=2, values=[[0.998], [0.002]])

cpd_alarm = TabularCPD(variable='Alarm', variable_card=2,
                       values=[[0.999, 0.71, 0.06, 0.05],
                               [0.001, 0.29, 0.94, 0.95]],
                       evidence=['Burglary', 'Earthquake'],
                       evidence_card=[2, 2])

cpd_johncalls = TabularCPD(variable='JohnCalls', variable_card=2,
                           values=[[0.95, 0.1], [0.05, 0.9]],
```

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

cpd_marycalls = TabularCPD(variable='MaryCalls', variable_card=2,
                      values=[[0.99, 0.3], [0.01, 0.7]],
                      evidence=['Alarm'], evidence_card=[2])

print()
print(cpd_burglary)
print()
print(cpd_earthquake)
print()
print(cpd_alarm)
print()
print(cpd_johncalls)
print()
print(cpd_marycalls)
print()

# Add CPTs to the model
model.add_cpds(cpd_burglary, cpd_earthquake, cpd_alarm, cpd_johncalls,
cpd_marycalls)

# Check if the model is valid
print("Model is valid:", model.check_model())

# Initialize the Variable Elimination Inference object
infer = VariableElimination(model)

# Inputs
evidence_no_burglary_earthquake = {'Burglary': 0, 'Earthquake': 0}

# Perform inference to get the probability distributions for each query

# Query 1: Probability that John called and Mary called, given no Burglary and no
Earthquake
query1 = infer.query(variables=['JohnCalls', 'MaryCalls','Alarm'],
evidence=evidence_no_burglary_earthquake)
print("Query 1:")
print("Probability that John called and Mary called, given no Burglary and no
Earthquake:")
print(query1)

# Query 2: Probability that John called
query2 = infer.query(variables=['JohnCalls'])
print("\nQuery 2:")
print("Probability that John called:")
print(query2)
```

```
# Query 3: Probability of Burglary given both John and Mary called
evidence_john_mary_called = {'JohnCalls': 1, 'MaryCalls': 1}
query3 = infer.query(variables=['Burglary'], evidence=evidence_john_mary_called)
print("\nQuery 3:")
print("Probability of Burglary given both John and Mary called:")
print(query3)
```

```
+-------------+-------+
| Burglary(0) | 0.999 |
+-------------+-------+
| Burglary(1) | 0.001 |
+-------------+-------+

+---------------+-------+
| Earthquake(0) | 0.998 |
+---------------+-------+
| Earthquake(1) | 0.002 |
+---------------+-------+

+------------+---------------+---------------+---------------+---------------+
| Burglary   | Burglary(0)   | Burglary(0)   | Burglary(1)   | Burglary(1)   |
+------------+---------------+---------------+---------------+---------------+
| Earthquake | Earthquake(0) | Earthquake(1) | Earthquake(0) | Earthquake(1) |
+------------+---------------+---------------+---------------+---------------+
| Alarm(0)   | 0.999         | 0.71          | 0.06          | 0.05          |
+------------+---------------+---------------+---------------+---------------+
| Alarm(1)   | 0.001         | 0.29          | 0.94          | 0.95          |
+------------+---------------+---------------+---------------+---------------+
```

```
+--------------+----------+----------+
| Alarm        | Alarm(0) | Alarm(1) |
+--------------+----------+----------+
| JohnCalls(0) | 0.95     | 0.1      |
+--------------+----------+----------+
| JohnCalls(1) | 0.05     | 0.9      |
+--------------+----------+----------+

+--------------+----------+----------+
| Alarm        | Alarm(0) | Alarm(1) |
+--------------+----------+----------+
| MaryCalls(0) | 0.99     | 0.3      |
+--------------+----------+----------+
| MaryCalls(1) | 0.01     | 0.7      |
+--------------+----------+----------+
```

QUERY OUTPUT

```
Query 1:
Probability that John called and Mary called, given no Burglary and no Earthquake:
+-------------+-------------+----------+-----------------------------------+
| JohnCalls   | MaryCalls   | Alarm    |   phi(JohnCalls,MaryCalls,Alarm) |
+=============+=============+==========+===================================+
| JohnCalls(0) | MaryCalls(0) | Alarm(0) |                            0.9396 |
+-------------+-------------+----------+-----------------------------------+
| JohnCalls(0) | MaryCalls(0) | Alarm(1) |                            0.0000 |
+-------------+-------------+----------+-----------------------------------+
| JohnCalls(0) | MaryCalls(1) | Alarm(0) |                            0.0095 |
+-------------+-------------+----------+-----------------------------------+
| JohnCalls(0) | MaryCalls(1) | Alarm(1) |                            0.0001 |
+-------------+-------------+----------+-----------------------------------+
| JohnCalls(1) | MaryCalls(0) | Alarm(0) |                            0.0495 |
+-------------+-------------+----------+-----------------------------------+
| JohnCalls(1) | MaryCalls(0) | Alarm(1) |                            0.0003 |
+-------------+-------------+----------+-----------------------------------+
| JohnCalls(1) | MaryCalls(1) | Alarm(0) |                            0.0005 |
+-------------+-------------+----------+-----------------------------------+
| JohnCalls(1) | MaryCalls(1) | Alarm(1) |                            0.0006 |
+-------------+-------------+----------+-----------------------------------+
```

```
Query 2:
Probability that John called:
+--------------+------------------+
| JohnCalls    |   phi(JohnCalls) |
+==============+==================+
| JohnCalls(0) |           0.9479 |
+--------------+------------------+
| JohnCalls(1) |           0.0521 |
+--------------+------------------+
```

```
Query 3:
Probability of Burglary given both John and Mary called:
+-------------+-----------------+
| Burglary    |   phi(Burglary) |
+=============+=================+
| Burglary(0) |          0.7158 |
+-------------+-----------------+
| Burglary(1) |          0.2842 |
+-------------+-----------------+
```