

Academic Year: 2024-2025

Semester: V

Class / Branch: TE/CSE-DS

Subject: Artificial Intelligence Lab

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Date Of Performance: 9/10/24

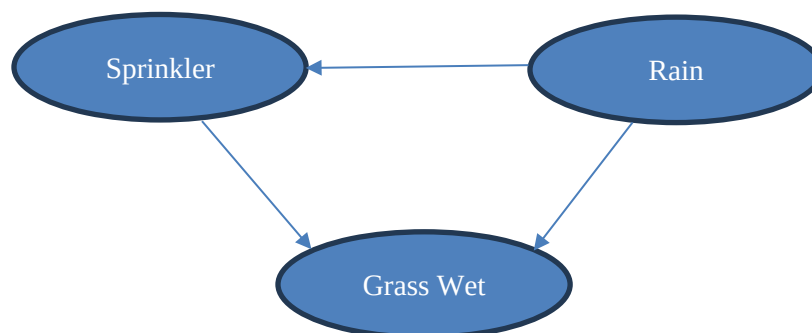
Date Of Submission: 9/10/24

Experiment No.10

Aim:- To implement a Bayesian Network using python.

Program:

1. Implement a Bayesian Network for the following and execute the following:



Rain	
R	~R
0.8	0.2

Sprinkler		
R	S	~S
F	0.5	0.5
T	0.9	0.1

WetGrass			
S	R	~W	W
~S	~R	0.99	0.01
S	~R	0.9	0.1
~S	R	0.8	0.2
S	R	0.0	1.0



a. Import necessary Libraries

```
[1] !pip install pgmpy

Collecting pgmpy
  Downloading pgmpy-0.1.26-py3-none-any.whl.metadata (9.1 kB)
Requirement already satisfied: networkx in /usr/local/lib/python3.10/dist-packages (from pgmpy) (3.3)
Requirement already satisfied: numpy in /usr/local/lib/python3.10/dist-packages (from pgmpy) (1.26.4)
Requirement already satisfied: scipy in /usr/local/lib/python3.10/dist-packages (from pgmpy) (1.13.1)
Requirement already satisfied: scikit-learn in /usr/local/lib/python3.10/dist-packages (from pgmpy) (1.5.2)
Requirement already satisfied: pandas in /usr/local/lib/python3.10/dist-packages (from pgmpy) (2.2.2)
Requirement already satisfied: pyparsing in /usr/local/lib/python3.10/dist-packages (from pgmpy) (3.1.4)
Requirement already satisfied: torch in /usr/local/lib/python3.10/dist-packages (from pgmpy) (2.4.1+cu121)
Requirement already satisfied: statsmodels in /usr/local/lib/python3.10/dist-packages (from pgmpy) (0.14.4)
Requirement already satisfied: tqdm in /usr/local/lib/python3.10/dist-packages (from pgmpy) (4.66.5)
Requirement already satisfied: joblib in /usr/local/lib/python3.10/dist-packages (from pgmpy) (1.4.2)
Requirement already satisfied: opt-einsum in /usr/local/lib/python3.10/dist-packages (from pgmpy) (3.4.0)
Requirement already satisfied: xgboost in /usr/local/lib/python3.10/dist-packages (from pgmpy) (2.1.1)
Requirement already satisfied: google-generativeai in /usr/local/lib/python3.10/dist-packages (from pgmpy) (0.7.2)
Requirement already satisfied: google-ai-generativelanguage==0.6.6 in /usr/local/lib/python3.10/dist-packages (from google-generativeai->pgmpy) (0.6.6)
Requirement already satisfied: google-api-core in /usr/local/lib/python3.10/dist-packages (from google-generativeai->pgmpy) (2.19.2)
Requirement already satisfied: google-api-python-client in /usr/local/lib/python3.10/dist-packages (from google-generativeai->pgmpy) (2.137.0)
Requirement already satisfied: google-auth==2.15.0 in /usr/local/lib/python3.10/dist-packages (from google-generativeai->pgmpy) (2.27.0)
Requirement already satisfied: protobuf in /usr/local/lib/python3.10/dist-packages (from google-generativeai->pgmpy) (3.20.3)
Requirement already satisfied: pydantic in /usr/local/lib/python3.10/dist-packages (from google-generativeai->pgmpy) (2.9.2)
Requirement already satisfied: typing-extensions in /usr/local/lib/python3.10/dist-packages (from google-generativeai->pgmpy) (4.12.2)
Requirement already satisfied: proto-plus<2.0.0dev, >=1.22.3 in /usr/local/lib/python3.10/dist-packages (from google-ai-generativelanguage==0.6.6->google-generativeai->pgmpy) (1.24.0)
Requirement already satisfied: python-dateutil<2.8.2 in /usr/local/lib/python3.10/dist-packages (from pandas->pgmpy) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas->pgmpy) (2024.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.10/dist-packages (from pandas->pgmpy) (2024.2)
Requirement already satisfied: threadpoolctl<=3.1.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn->pgmpy) (3.5.0)
Requirement already satisfied: patsy<0.5.6 in /usr/local/lib/python3.10/dist-packages (from statsmodels->pgmpy) (0.5.6)
Requirement already satisfied: packaging<21.3 in /usr/local/lib/python3.10/dist-packages (from statsmodels->pgmpy) (24.1)
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from torch->pgmpy) (3.16.1)
Requirement already satisfied: sympy in /usr/local/lib/python3.10/dist-packages (from torch->pgmpy) (1.13.3)
Requirement already satisfied: Jinja2 in /usr/local/lib/python3.10/dist-packages (from torch->pgmpy) (3.1.4)
Requirement already satisfied: fsspec in /usr/local/lib/python3.10/dist-packages (from torch->pgmpy) (2024.6.1)
Requirement already satisfied: nvidia-nccl-cu12 in /usr/local/lib/python3.10/dist-packages (from xgboost->pgmpy) (2.23.4)
Requirement already satisfied: googleapis-common-protos<2.0.0dev, >=1.56.2 in /usr/local/lib/python3.10/dist-packages (from google-api-core->google-generativeai->pgmpy) (1.65.0)
Requirement already satisfied: requests<3.0.0dev, >=2.18.0 in /usr/local/lib/python3.10/dist-packages (from google-api-core->google-generativeai->pgmpy) (2.32.3)
Requirement already satisfied: cachetools<6.0, >=2.0.0 in /usr/local/lib/python3.10/dist-packages (from google-auth==2.15.0->google-generativeai->pgmpy) (5.5.0)
Requirement already satisfied: pyasn1-modules<=0.2.1 in /usr/local/lib/python3.10/dist-packages (from google-auth==2.15.0->google-generativeai->pgmpy) (0.4.1)
5s completed at 12:51 PM
```

```
Requirement already satisfied: threadpoolctl<=3.1.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn->pgmpy) (3.5.0)
Requirement already satisfied: patsy<0.5.6 in /usr/local/lib/python3.10/dist-packages (from statsmodels->pgmpy) (0.5.6)
Requirement already satisfied: packaging<21.3 in /usr/local/lib/python3.10/dist-packages (from statsmodels->pgmpy) (24.1)
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from torch->pgmpy) (3.16.1)
Requirement already satisfied: sympy in /usr/local/lib/python3.10/dist-packages (from torch->pgmpy) (1.13.3)
Requirement already satisfied: Jinja2 in /usr/local/lib/python3.10/dist-packages (from torch->pgmpy) (3.1.4)
Requirement already satisfied: fsspec in /usr/local/lib/python3.10/dist-packages (from torch->pgmpy) (2024.6.1)
Requirement already satisfied: nvidia-nccl-cu12 in /usr/local/lib/python3.10/dist-packages (from xgboost->pgmpy) (2.23.4)
Requirement already satisfied: googleapis-common-protos<2.0.0dev, >=1.56.2 in /usr/local/lib/python3.10/dist-packages (from google-api-core->google-generativeai->pgmpy) (1.65.0)
Requirement already satisfied: requests<3.0.0dev, >=2.18.0 in /usr/local/lib/python3.10/dist-packages (from google-api-core->google-generativeai->pgmpy) (2.32.3)
Requirement already satisfied: cachetools<6.0, >=2.0.0 in /usr/local/lib/python3.10/dist-packages (from google-auth==2.15.0->google-generativeai->pgmpy) (5.5.0)
Requirement already satisfied: pyasn1-modules<=0.2.1 in /usr/local/lib/python3.10/dist-packages (from google-auth==2.15.0->google-generativeai->pgmpy) (0.4.1)
Requirement already satisfied: rsa<=3.1.4 in /usr/local/lib/python3.10/dist-packages (from google-auth==2.15.0->google-generativeai->pgmpy) (4.9)
Requirement already satisfied: six in /usr/local/lib/python3.10/dist-packages (from patsy<0.5.6->statsmodels->pgmpy) (1.16.0)
Requirement already satisfied: httplib2<1.0dev, >=0.19.0 in /usr/local/lib/python3.10/dist-packages (from google-api-python-client->google-generativeai->pgmpy) (0.22.0)
Requirement already satisfied: google-auth-httplib2<1.0.0, >=0.2.0 in /usr/local/lib/python3.10/dist-packages (from google-api-python-client->google-generativeai->pgmpy) (0.2.0)
Requirement already satisfied: uritemplate<5, >=3.0.1 in /usr/local/lib/python3.10/dist-packages (from google-api-python-client->google-generativeai->pgmpy) (4.1.1)
Requirement already satisfied: MarkupSafe<2.0 in /usr/local/lib/python3.10/dist-packages (from Jinja2->torch->pgmpy) (2.1.5)
Requirement already satisfied: pydantic-core==2.23.4 in /usr/local/lib/python3.10/dist-packages (from pydantic->google-generativeai->pgmpy) (2.23.4)
Requirement already satisfied: mpmath<1.4, >=1.1.0 in /usr/local/lib/python3.10/dist-packages (from sympy->torch->pgmpy) (1.3.0)
Requirement already satisfied: grpcio<2.0dev, >=1.33.2 in /usr/local/lib/python3.10/dist-packages (from google-api-core[grpc]==2.0.*;!=2.1.*,!=2.10.*,!=2.2.*,!=2.3.*,!=2.4.*,!=2.5.*,!=2.6.*->google-api-core->google-generativeai->pgmpy) (1.65.0)
Requirement already satisfied: grpcio-status<2.0dev, >=1.33.2 in /usr/local/lib/python3.10/dist-packages (from google-api-core[grpc]==2.0.*;!=2.1.*,!=2.10.*,!=2.2.*,!=2.3.*,!=2.4.*,!=2.5.*,!=2.6.*->google-api-core->google-generativeai->pgmpy) (1.65.0)
Requirement already satisfied: pyasn1<0.7.0, >=0.4.6 in /usr/local/lib/python3.10/dist-packages (from pyasn1-modules==0.2.1->google-auth==2.15.0->google-generativeai->pgmpy) (0.6.1)
Requirement already satisfied: charset-normalizer<4, >=2 in /usr/local/lib/python3.10/dist-packages (from requests<3.0.0dev, >=2.18.0->google-api-core->google-generativeai->pgmpy) (3.3.2)
Requirement already satisfied: idna<4, >=2.5 in /usr/local/lib/python3.10/dist-packages (from requests<3.0.0dev, >=2.18.0->google-api-core->google-generativeai->pgmpy) (3.10)
Requirement already satisfied: urllib3<3, >=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests<3.0.0dev, >=2.18.0->google-api-core->google-generativeai->pgmpy) (2.2.3)
Requirement already satisfied: certifi<=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests<3.0.0dev, >=2.18.0->google-api-core->google-generativeai->pgmpy) (2024.8.30)
Downloading pgmpy-0.1.26-py3-none-any.whl (2.0 MB)
Installing collected packages: pgmpy
Successfully installed pgmpy-0.1.26
2.0/2.0 MB 25.6 MB/s eta 0:00:00

[2] Suggested code may be subject to a license | MariosRichards/BES_analysis_code
from pgmpy.models import BayesianModel
from pgmpy.factors.discrete import TabularCPD
from pgmpy.inference import VariableElimination
5s completed at 12:51 PM
```



b. Define the model structure

```
model=BayesianModel([('Rain','wetgrass'),('sprinkler','wetgrass'),('rain','sprinkler')])
```

WARNING:pgmpy:BayesianModel has been renamed to BayesianNetwork. Please use BayesianNetwork class, BayesianModel will be removed in future.

c. Define Conditional Probability Distributions and print the table.

```
cpd_rain=TabularCPD(variable="Rain",variable_card=2,values=[[0.8],[0.2]])
```

```
[12] print(cpd_rain)
```

	Rain(0)	Rain(1)
0.2	0.2	0.8

```
cpd_sprinkler=TabularCPD(variable="sprinkler",variable_card=2,values=[[0.5,0.1],[0.5,0.9]],evidence=["rain"],evidence_card=[2])
```

```
print(cpd_sprinkler)
```

rain	sprinkler(0)	sprinkler(1)
0.5	0.5	0.1
0.9	0.5	0.9

```
cpd_wetgrass=TabularCPD(variable="wetgrass",variable_card=2,values=[[0.99,0.9,0.8,0.0],[0.01,0.1,0.2,1.0]],evidence=["rain","sprinkler"],evidence_card=[2,2])
```

```
print(cpd_wetgrass)
```

rain	sprinkler	wetgrass(0)	wetgrass(1)
0.99	0.9	0.8	0.0
0.01	0.1	0.2	1.0



d. Print the model

```
0s [✓] ▶ print(model)
BayesianModel with 3 nodes and 3 edges
```

e. Add CPD to the model

```
0s [✓] [27] model.add_cpds(cpd_rain,cpd_sprinkler,cpd_wetgrass)
```

f. Validate the model

```
0s [✓] [29] assert model.check_model()
```

g. Perform Inference

```
0s [✓] ▶ inference=VariableElimination(model)
```

h. Execute query 1: Probability of WetGrass being True given that it rained and no springler



```
[31] prob_wetgrass=inference.query(variables=["wetgrass"],evidence={"rain":1,"sprinkler":0})
      print(prob_wetgrass)
```

WARNING:pgmpy:BayesianModel has been renamed to BayesianNetwork. Please use BayesianNetwork class, BayesianModel will be removed in future.
WARNING:pgmpy:BayesianModel has been renamed to BayesianNetwork. Please use BayesianNetwork class, BayesianModel will be removed in future.

wetgrass	phi(wetgrass)
wetgrass(0)	0.8000
wetgrass(1)	0.2000

- Execute query 2: Probability of WetGrass being true given that Rain and springler is true

```
prob_wetgrass=inference.query(variables=["wetgrass"],evidence={"rain":1,"sprinkler":1})
print(prob_wetgrass)
```

WARNING:pgmpy:BayesianModel has been renamed to BayesianNetwork. Please use BayesianNetwork class, BayesianModel will be removed in future.
WARNING:pgmpy:BayesianModel has been renamed to BayesianNetwork. Please use BayesianNetwork class, BayesianModel will be removed in future.

wetgrass	phi(wetgrass)
wetgrass(0)	0.0000
wetgrass(1)	1.0000