Warsaw University of Technology
Faculty of Electronics and Information Technology
Specialization: Computer Science
Course: Introduction to Artificial Intelligence

PROJECT DOCUMENTATION

Bayesian Network

Author:
Monika Jung

Student ID:
331384

Objective

The goal of this task was to construct a Bayesian Network that models the relationship between the presence of a PhD student (K.) in her office, the status of the light in the room, and her login status in Microsoft Teams. The main question was: **What is the influence of knowing that K. is logged into Teams on the belief that the light in her office is on?**

Scenario Description

The following probabilistic dependencies are assumed:

- K. is present in her office 40% of the time. The remaining 60% she works remotely.
- When she is present:
  - The light is on 50% of the time.
  - She is logged into Microsoft Teams 80% of the time.
- When she is absent:
  - The light is left on 5% of the time.
  - She is logged into Microsoft Teams 5% of the time.

Bayesian Network Structure

We defined three discrete variables:

- `Room`: whether K. is present in her office (`present`/`absent`)
- `Light`: whether the light is on (`on`/`off`)
- `MSTeams`: whether K. is logged into Microsoft Teams (`on`/`off`)

The dependencies are represented by the following directed acyclic graph:

$$\texttt{Room} \rightarrow \texttt{Light}$$

$$\texttt{Room} \rightarrow \texttt{MSTeams}$$

Implementation

The network was implemented in Python using the `pgmpy` library. The conditional probability tables (CPTs) were defined based on the scenario, and inference was performed using the `VariableElimination` algorithm.

Results

Two queries were evaluated:

1. Unconditional Probability of Light Being On

```
P(Light=on)  0.2300
```

2. Conditional Probability Given Teams Status

Given that the student sees K. is **logged in to Microsoft Teams**, the probability that the light in her office is on increases to:

```
P(Light=on | MSTeams=on)  0.4614
```

Manual Calculations (Verification)

To verify the correctness of the network, we calculate manually the conditional probability:

$$P(\text{Light} = \text{on} \mid \text{MSTeams} = \text{on})$$

We use the law of total probability and sum over the hidden variable `Room`:

$$\begin{aligned}P(L = \text{on}, T = \text{on}) = P(R = \text{present}) \cdot P(T = \text{on} \mid R = \text{present}) \cdot P(L = \text{on} \mid R = \text{present})\\ + P(R = \text{absent}) \cdot P(T = \text{on} \mid R = \text{absent}) \cdot P(L = \text{on} \mid R = \text{absent})\end{aligned}$$

Substituting the known probabilities:

$$= 0.4 \cdot 0.8 \cdot 0.5 + 0.6 \cdot 0.05 \cdot 0.05 = 0.16 + 0.0015 = 0.1615$$

Now we calculate the full probability of `MSTeams = on`:

$$P(T = on) = P(R = present) \cdot P(T = on \mid R = present) + P(R = absent) \cdot P(T = on \mid R = absent)$$

$$= 0.4 \cdot 0.8 + 0.6 \cdot 0.05 = 0.32 + 0.03 = 0.35$$

Finally, we compute the conditional probability:

$$P(L = on \mid T = on) = \frac{P(L = on, T = on)}{P(T = on)} = \frac{0.1615}{0.35} \approx \boxed{0.4614}$$

Legend:

- T - MS Teams status (on/off)
- L - Room light status (on/off)
- R - Room presence (present/absent)

This exactly matches the result returned by the Bayesian network inference engine, confirming that the model behaves as expected.

Conclusion

The Bayesian Network successfully models the probabilistic relationships described in the scenario. The presence of evidence (`MSTeams=on`) significantly increases the belief that the light in the office is on — from about 23% to 46%.