PROJECT REPORT

On

MYSTERY SOLVER

UTILIZING

BAYESIAN NETWORK

By

Pial Islam

1921506042

Rafiqul Islam

1821991042

Sibgat Ullah Galib

1911438642

To

Mohammad Shifat-E-Rabbi (MSRb)

Date

01-12-2024

ABSTRACT

The "Mystery Solver" application is designed to help users solve fictional mystery scenarios using Bayesian networks. By applying Bayesian inference, the system evaluates clues and evidence provided by the user to calculate the probabilities of various suspects being guilty. This interactive tool is educational, demonstrating the power of Bayesian reasoning

INTRODUCTION

The "Mystery Solver" application leverages Bayesian networks to provide an engaging platform for solving fictional mystery scenarios by reasoning through uncertain and incomplete information. Users can input clues and evidence, and the system employs Bayesian inference to dynamically calculate and update the probabilities of various suspects being guilty. By structuring this process mathematically, the application highlights the utility of Bayesian reasoning in evaluating hypotheses under uncertainty. This tool is designed to be both educational and entertaining, offering users an intuitive and interactive way to explore complex problem-solving while demonstrating the principles of probabilistic reasoning.

SYSTEM DESIGN

The application consists of the following components:

1. **Inference Engine**

   Implements Bayesian reasoning using a predefined Bayesian network.

2. **Scenario Database**

   Contains fictional cases, suspects, and potential evidence.

3. **Backend Server**

   Processes user inputs and computes probabilities.

Now, to understand the project process a little bit better, we need to know what “Bayesian Network” is and how it is helping to make this project.

BAYESIAN NETWORK

The Bayesian network in the "Mystery Solver" application is a graphical model that represents the probabilistic relationships between various factors in a mystery scenario. It is structured as a directed acyclic graph (DAG), where:

Nodes

Represent variables such as suspects, evidence, motives, and alibis.

Edges

Represent causal or dependency relationships between these variables. For example, a motive might increase the likelihood of a suspect committing a crime, or an alibi might reduce it.

Conditional Probability Tables (CPTs)

Each node contains a CPT that quantifies the probabilistic relationships between a node and its parent nodes. For example, the probability of "Fingerprint Evidence" given a suspect's guilt might be high, while the probability of the same evidence for an innocent suspect might be very low.

Example of Bayesian Network to create a better understanding:

Parent Nodes:

Motive (e.g. Financial Trouble, Revenge)

Indicates whether a suspect had a reason to commit the crime.

Opportunity (e.g. Proximity to the Crime Scene)

Suggests whether the suspect had the chance to act.

Intermediate Nodes:

Physical Evidence (e.g. Fingerprints, Footprints)

Represents tangible clues linking a suspect to the crime.

Witness Statements:

Accounts of who was seen or heard near the crime scene.

Child Nodes:

Guilt of Suspects

Represents the overall probability of each suspect being guilty, influenced by all the evidence and relationships in the network.

By combining these nodes, edges, and probabilities, the Bayesian network evaluates the combined likelihood of guilt for each suspect, updating dynamically as new evidence is introduced. This framework ensures that the reasoning is structured, transparent, and grounded in probabilistic principles.

IMPLEMENTATION

Tools & Technology:

Programming Language

Python

Libraries

1.

pgmpy

Bayesian network construction and inference.

2.

Flask

The Backend API

Key Algorithm

Bayesian Inference

Bayesian inference updates the posterior probability P(H|E) of a hypothesis H given evidence E:

$$P(H|E) = [\{P(E|H) \cdot P(H)\}/P(E)]$$

Where;

P(H)

Prior probability of the hypothesis.

P(E|H)

Likelihood of evidence given the hypothesis.

P(E)

Marginal probability of the evidence.

Implementation Steps

1.

Initialize the Bayesian network with prior probabilities and CPTs.

2.

Accept user input for evidence nodes.

3.

Update probabilities using inference algorithms (e.g. variable elimination).

4.

Display updated probabilities for suspects.

EVALUATION

Test Cases:

Test cases simulate user inputs for different scenarios to validate probability updates.

Example:

Evidence

"Alice has a motive" and "Fingerprints on the safe."

Expected Result

Alice’s probability increases significantly.

Accuracy and Performance:

The Bayesian network's outputs are validated against manually calculated probabilities to ensure accuracy. Performance optimization techniques, such as caching results for common queries, are implemented to improve responsiveness.

RESULTS

The "Mystery Solver" application successfully demonstrates Bayesian reasoning:

1.

Accurate inference results based on user-provided evidence.

2.

Enhanced user engagement through gamified mystery-solving scenarios.

CONCLUSION

The "Mystery Solver" application successfully demonstrates the potential of Bayesian networks to model and solve complex problems involving uncertainty, such as fictional mystery scenarios. By allowing users to input evidence and observe how probabilities are updated dynamically, the tool provides an intuitive way to understand Bayesian reasoning in action. The structured, probabilistic approach ensures that all evidence is considered systematically, providing results that are both logical and transparent. Beyond its educational value, the application also offers an engaging and interactive experience, making it suitable for a wide audience, including students, educators, and enthusiasts of mystery-solving games. The project effectively combines gamification and learning, showcasing how Bayesian inference can be applied to real-world reasoning challenges in an accessible and entertaining way. Through its clear and intuitive design, the "Mystery Solver" not only simplifies the complex mathematics behind Bayesian networks but also inspires curiosity and critical thinking in its users.