Adventure Quest Game Utilizing Factor Graphs

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***Abstract*— Adventure Quest, an interactive fiction game that involves dynamic decision-making using factor graphs. Factor graphs use probabilistic reasoning to deal with complex relationships between story objects and create a dynamic and customized gaming experience. Each player's decision influences the story, rendering each adventure a unique one. The author presents the use of factor graphs in game design, from which their use is described to arrange decision logic as well as facilitate narrative coherence. Through Adventure Quest, it depicts how probabilistic models enhance interactivity and consequently create more interactive and responsive tales. The outcomes demonstrate the viability of factor graphs to guide dynamic stories and offer increased engagement with each play through being distinct. This study also explains the merits and demerits of implementing factor graphs within game worlds and compares them to other approaches such as decision trees and neural networks. The study concludes that probabilistic graphical models are a realistic approach to structuring flexible stories in computer games.**

I. Introduction

Adventure Quest is an innovative, interactive, text-based adventure game designed to provide players with an immersive experience where their choices directly influence the game's progression. The game's narrative unfolds dynamically based on the player's actions, which affect their health, reputation, and combat ability. To achieve this dynamic decision-making, the game utilizes probabilistic models in the form of factor graphs, which govern the outcomes of key actions.

The game is set in Dhaka, Bangladesh, and presents players with iconic locations such as Lalbagh Fort, Sadarghat, and the National Museum. Players must navigate these locations, choose between various actions, and interact with the environment to complete quests and overcome challenges.

At its core, Adventure Quest is designed to integrate probabilistic decision-making within a text-based role-playing game (RPG). The use of factor graphs allows for an adaptive storyline that changes with each player's choice. The core focus of this project is to demonstrate how factor graphs can be used to integrate probabilistic reasoning into a real-world interactive application like an adventure game.

II. Problem Statement

The primary goal of this project was to create an interactive game that simulates decision-making through the use of factor graphs. Unlike traditional games with linear narratives, Adventure Quest uses dynamic storytelling where the game's progression depends on the player's probabilistic outcomes.

The probabilistic decision-making model allows for multiple potential outcomes from a single action, ensuring the game remains replayable and engaging. By leveraging factor graphs, the game can adapt to player choices, adjusting health, reputation, and combat ability dynamically.

The project aimed to address the following challenges:

- **Probabilistic Modeling**: Integrating a factor graph into the game to model dependencies between key variables like health, reputation, and combat ability.
- **User Interaction:** Designing an intuitive GUI for players to interact with the game, while maintaining a complex probabilistic backend.
- **Replayability:** Ensuring that each play through offers unique outcomes based on the player's choices, influenced by random events and probabilistic factors.

III. Related Work

The concept of using probabilistic models and graphical representations in game design is not new. Several works have explored using probabilistic reasoning in game theory and AI systems. For example, Monopoly Plus and Dungeons and Dragons utilize random number generation (RNG) and chance cards to simulate probabilistic events.

In the AI gaming domain, Monte Carlo Tree Search (MCTS) and Bayesian networks are widely used for decision-making in strategy games [1][2]. These systems allow games to dynamically adapt to player choices, much like how factor graphs influence decision-making in this project.

However, factor graphs offer a more structured and scalable approach, making them suitable for more complex game logic where multiple variables are interdependent. Unlike traditional random number-based decisions, factor graphs provide a structured probabilistic model to simulate realistic game mechanics, which can adapt over time based on player interactions.

IV. SYSTEM DESIGN

A. *Factor Graph Overview*

Factor graphs are probabilistic graphical models that represent the conditional dependencies between variables. In this project, we used factor graphs to model key game mechanics: health, reputation, combat ability, and quest progress. These variables influence each other and are affected by player decisions.

- Health: Represents the player's vitality and is one of the most crucial variables affecting gameplay.
- Reputation: Reflects how others perceive the player based on their actions.
- Combat Ability: Influenced by health, it determines the player's chances of winning battles.
- Quest Progress: Tracks the player's advancement in the primary quest of the game.

Each of these variables is represented by a discrete factor in the factor graph. The following probabilistic dependencies were modeled:

- Health → Reputation: Health impacts how others perceive the player.
- Reputation → Quest Progress: A positive reputation leads to better quest outcomes.
- Health → Combat Ability: Higher health results in a higher chance of winning fights.

B. *Factor Graph Construction*

The construction of the factor graph is done using pgmpy, a Python library for working with probabilistic graphical models. Each variable’s probability distribution is defined, and the dependencies between variables are represented as edges in the graph. This allows us to perform inference on the graph to determine the outcomes of actions, which are then used to dynamically adjust the game state.

The use of pgmpy enables factor inference, allowing the model to calculate the probability of certain outcomes based on the player's actions.

V. GAME MECHANICS & FEATURES

A. *Location Based Interaction*

The game features several iconic locations in Dhaka, such as Lalbagh Fort, Sadarghat, and National Museum. Players can visit these locations and choose from a variety of actions:

- Explore: Players explore the area, which may have positive or negative outcomes.
- Rest: Players can recover health by resting.
- Fight: Combat scenarios arise when players encounter enemies. The outcome is probabilistically determined by the combat ability factor.
- Random Event: Triggering random events adds unpredictability, such as finding items or gaining reputation.

Each location provides sub-options for the player to choose from, allowing for flexible, non-linear gameplay.

B. *Combat and Random Events*

Combat is influenced by the combat ability, which is probabilistically determined by the player’s health and reputation. Players can fight enemies such as bandits or wild animals, and the outcome of combat is determined by a probabilistic calculation based on the factor graph.

Random events further complicate the gameplay by providing unexpected outcomes, such as:

- Finding an item: Items can be found to help the player.
- Gaining health: Players may discover herbs or other items to restore health.
- Fight Bandits: Bandits appear, and the player must choose to fight or negotiate.

VI. Results & Evaluation

A. *Evaluation of Factor Graph Performance*

The factor graph successfully simulated decision-making processes. The health and reputation factors influenced player actions, with combat ability and quest progress being dynamically updated using factor graph inference.

The game was evaluated in multiple scenarios to test how the factor graph influenced the outcome of each player's decisions. Each decision (e.g., exploring, fighting, resting) triggered changes in game state variables based on the probabilistic model.

B. *Feedback and Playability*

The feedback from players indicated that the game was engaging, with each playthrough offering a unique experience due to the random events and dynamic changes in the game state. However, players noted that the complexity of the factor graph could be difficult to understand for those unfamiliar with probabilistic models.

VII. Future Works

A. *Expanding the Game World*

Future iterations of the game could feature additional locations in Dhaka, each with its own unique quests and challenges. Expanding the game world would provide players with more opportunities to explore and interact.

B. *AI-Driven NPCs*

Adding NPCs with unique dialogue and quests could add depth to the game, making it even more immersive. These NPCs could offer rewards or penalties based on the player's reputation and previous decisions.

C. *Multiplayer Integration*

Introducing multiplayer functionality would allow players to collaborate on quests or compete to uncover the treasure first. This would add a new layer of complexity and replayability to the game.

D. *Enhanced Combat Systen*

The combat system could be expanded to include tactical elements like positioning, special abilities, and enemy strategies. This would provide a more dynamic combat experience.

VIII. Conclusion

In this project, Adventure Quest successfully demonstrates the use of factor graphs for dynamic decision-making in a text-based adventure game. The integration of probabilistic modeling allows the game to adapt to player choices, creating a replayable and immersive experience.

The combination of probabilistic inference with Tkinter for the graphical interface creates a solid foundation for an interactive adventure game. Future work on expanding the game world, improving AI interactions, and adding multiplayer functionality would further enhance the game's complexity and player engagement.

References

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