Creation of a Mobile App: Kazakh national game - Togyz Qumalaq

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I. Introduction

Our project focuses on preserving and improving the appreciation of Kazakh culture, particularly through the national game "Togyz Qumalaq." We are addressing the challenge of cultural practices being overshadowed by modern advancements by creating an interactive mobile application. This initiative is crucial for keeping "Togyz Qumalaq" noted and accessible in the future.

The mobile application features include:

- A modernized digital version of the traditional "Togyz Qumalaq" game board.
- An AI offering three levels of difficulty to suit all players.
- Simple, intuitive gameplay designed to be accessible to newcomers.
- An online multiplayer function to promote global interaction and cultural sharing.

By transforming "Togyz Qumalaq" into a digital format, our project not only preserves this important aspect of Kazakh heritage but also makes it engaging and educational for users worldwide.

II. Background and Related Work

Togyz Kumalak is a traditional Kazakh game played by approximately 190,000 professional players in Kazakhstan [1]. This two-player game is akin to chess, demanding strategic planning and pattern recognition skills. The winner is determined by the number of points amassed in their "Kazan" (scoring area) by the end of the game [3].

Although there are existing digital versions of Togyz Kumalak, many of these applications suffer from poor design and lackluster user experiences, which fail to engage players effectively. Moreover, there is a notable gap in the use of advanced technologies like Reinforcement Learning (RL) in the development of Togyz Kumalak applications.

In contrast, games like chess and Go have seen significant advancements with AI systems such as AlphaZero [2], which has achieved performance levels well beyond human capabilities. However, such sophisticated AI applications have not yet been applied to Togyz Kumalak. This project represents a pioneering effort to employ RL techniques, specifically to enhance the gameplay and strategy of Togyz Kumalak, marking a significant innovation in the digital adaptation of traditional Kazakh games.

III. Project Approach

A. Development of the iOS/Android Application

We chose Flutter for the development of our mobile application, enabling us to build a high-quality, visually appealing interface from scratch. This choice also supports the efficient implementation of both the aesthetic and functional elements of the app. Our app features five main pages, each designed to enhance the user experience and functionality 1:

- **Discovery Page:** This page provides users with an introduction to the game, including its rules and historical background, helping new players understand and appreciate the cultural significance of "Togyz Qumalaq."
- **Friends Page:** Allows users to connect and play with friends, improving the social aspect of the game.
- **Play Game Page:** Users can search for new opponents, making it easy to find matches and engage in gameplay.
- **Statistics Page:** Displays the player's game statistics, including wins, losses, and draws, offering insights into their performance and progress.
- **Profile Page:** Contains user information and settings, allowing players to customize their experience and manage their account details.

In addition to these core pages, our app includes essential user functionalities such as login and registration processes, ensuring a secure and personalized user experience.

B. AI Model Implementation

To cater to players of varying skill levels, we implemented an artificial intelligence (AI) model with three difficulty settings: Easy, Medium, and Hard.

- **Easy Level:** Uses Minimax with a depth of 1.
- **Medium Level:** Uses Minimax with a depth of 3.
- **Hard Level:** Uses the trained RL model

We used two primary approaches for our AI models:

Min-Max Algorithm The Minimax algorithm is a strategy used in artificial intelligence (AI) to reduce potential losses in the worst-case scenario [5]. This algorithm is particularly useful in games, where it helps determine the best possible move assuming the opponent is also playing their best. We adopted this algorithm to create two AI difficulty settings for our "Togyz Qumalaq" game app.

The Minimax algorithm determines the optimal move by evaluating rewards based on the current state of the game board.

Pit Difference Reward: This reward is calculated from the difference in the number of pits filled by the opponent versus the player. It indicates whether the player is currently at an advantage or disadvantage based on the game's resources.

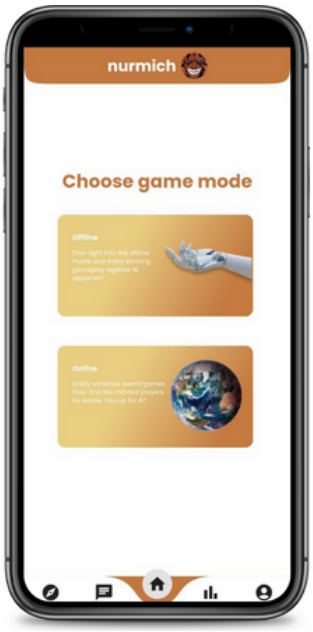

Fig. 1. Application design with 5 main pages

Tuzdyk Point: The Tuzdyk holds strategic importance in the game, similar to earning a steady income. Gaining control of a Tuzdyk early on is advantageous as it accumulates points throughout the game. We value the Tuzdyk by estimating the average total moves in a game to be 60. Therefore, the reward for holding a Tuzdyk is set as ”60 - Number of moves played.” This encourages the AI to consider strategic moves early in the game to secure this benefit.

Reinforcement Learning To build a strong AI for our ”Togyz Qumalaq” game, we used a method known as a Deep Q-Network (DQN). We created a special setting for this, called TogyzKumalakEnv, with the help of the OpenAI Gym interface [6], specifically designed for our game.

The AI can choose from 9 different actions, each linked to a move in one of the game’s pits. It views the game through a 22-element vector that describes the current game state. This includes the number of stones in each pit, the scores in each player’s ”kazan” (the scoring area), and the position of ”tuzdyq” (special pits).

Our DQN model uses a three-layer neural network that takes the game’s current state as input and suggests the best move as output. The training of this model focused on improving how the game is played by using a combination of rewards for winning and penalties for mistakes or losing. Specifically, we added a penalty of -50 for wrong moves, +100 for a win, and -100 for a loss, which helps the AI learn the right strategies and improve its gameplay.

After training for 1000 epochs for parameters on Table I, our model achieved a total reward of -1220 for a batch of 64 games. Considering the significant penalties for incorrect moves, this result shows effective learning.

TABLE I
TRAINING PARAMETERS FOR DEEP Q-NETWORK

Parameter	Value
Learning Rate	0.001
Discount Factor (Gamma)	0.99
Batch Size	64
Epsilon	1.0
Epsilon Minimal	0.995
Epsilon decay	0.01

C. Multiplayer Functionality

To add multiplayer functionality to our app, we set up a backend server using Django, hosted on ps.kz [4]. This server supports several important features needed for playing the game online:

- Database Integration: We created a database to save game histories and player statistics. This lets players see how they’ve improved over time and supports features like leaderboards.
- Real-Time Connection: We used web sockets to build a system that allows for the creation and management of game rooms where players can meet and play.
- Matchmaking System: We developed a session queue to handle the process of pairing players. This system places players in a waiting area until it finds a suitable match for them to play against.

These improvements not only enhance the multiplayer experience but also help build a global community by connecting players from different parts of the world.

IV. PROJECT EXECUTION

For the last two semesters, our project evolved significantly from its initial concept. Initially, we aimed to develop basic game functionality, pitting players against a Minimax algorithm. The first challenge we encountered was determining the appropriate reward evaluation for the AI model, which was crucial for developing the min-max effectively.

During the first semester, we successfully implemented the fundamental functionalities of the app, but it lacked polished design and robust backend communication. As we transitioned into the second semester, our focus shifted towards enhancing the visual appeal and user experience of the application. We revamped the design and began server-side development to integrate multiplayer features, as outlined in our Project Approach. Significant UI/UX decisions were made during this phase, leading to the creation of five main pages within the app, including a dedicated profile page for users.

Furthermore, we aimed to make the game more engaging for players by incorporating player statistics. This addition was intended to provide users with insightful feedback on their performance and foster a competitive environment.

Concurrently, we developed a Reinforcement Learning (RL) model using a simple three-layer fully connected network architecture for Deep Q-Networks (DQN). Adapting the game agent to continuously play against itself required

modifications to facilitate its learning process. This self-play mechanism was critical in refining the AI's strategy and gameplay skills.

Throughout these semesters, we faced various challenges, including AI training complexities and integrating sophisticated multiplayer functionalities. Each issue was addressed through iterative testing and feedback, allowing us to refine our approach and produce a more polished and engaging game application.

V. Evaluation

To assess the effectiveness of our game and determine whether it addressed the issues outlined in the introduction, we conducted a user experience evaluation involving 15 players. We asked them to rate the game on three specific aspects: functionality, design, and encouragement, each on a scale of 1 to 5.

Here's a summary of the evaluation:

- Functionality: Users generally rated this aspect highly, indicating that the game operates smoothly and meets their expectations for basic performance.
- Design: Similar to functionality, the design of the game was well-received, with users appreciating the aesthetic and usability improvements implemented in the second semester.
- Encouragement: While the ratings for encouragement were also positive, suggesting that the game was engaging, participants provided constructive feedback for further enhancements. They recommended the addition of a global ranking system, a mechanism for searching and matching opponents based on rating, and a feature to search for and play with friends.

These results suggest that while the game is robust in terms of functionality and design, incorporating additional social and competitive elements could enhance user engagement and satisfaction.

VI. Conclusion and possible future work

In conclusion, our project has successfully developed a game application that includes basic gameplay functionalities, advanced AI using a Minimax algorithm, also a Reinforcement Learning DQN, and a user-friendly design. The implementation of multiplayer capabilities and player statistics has further improved the gaming experience. Feedback gathered from our user evaluation shows a positive response towards the game's functionality and design. However, users also stated that the application could be more interactive and include competitive features.

Based on the feedback received, several improvements can be considered for further development of this project:

- Elo Rating System: Implementing an Elo rating system that exists in many other competitive games like chess.
- Global Rating Leaderboard: In order to make the game more competitive, global rating leaderboard can be implemented.
- Develop Friends System: Developer Friends system where players can add and search for friends easily in order to play with them.

By integrating the above mentioned features, we aim to improve the game's functionalities that makes the game more convenient for users, therefore, attracts more players.

References

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