

Java Final Project Report

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1 Introduction

According to [2], Texas hold 'em (also known as Texas holdem, hold 'em, and holdem) is one of the most popular variants of the card game of poker. Because of the game's level of complexity, it has received some attention from academics. Several quantitative models and different artificial intelligence systems have been proposed. Noticeably, computer Poker Research Group (CPRG) at the University of Alberta has developed a poker playing program called Cepheus. From its publication[1] we can conclude that an optimal counter-strategy to Cepheus can only win 0.000986 big blinds per game on expectation, which make it impossible for a human to win in life time. Hence, in this project, we will build a Texas hold 'em game from scratch and implement an artificial intelligence system that play such game with an arbitrary number of real users.

2 Task Description

Overall, in this project, we will build a Texas hold 'em game from scratch, which includes a front-end UI with necessary animations; a backend cloud service along with a cloud database that supports all necessary RESTful services and communications between users while playing. Plus, an advanced AI system that can play the game optimally should also be included. Detailed requirements are described in following sections.

2.1 Game System - Haoze He

Haoze He takes charge of the Texas Hold'em Game system. The game system contains all the structure for a whole Texas Hold'em Game. The system can finish the followings operations automatically in the game:

- Give hole cards to each player before the flop.
- Receive bet, fold, and raise decision from each player including AIs until no more bet. The decision starts from the small blind.
- Maintain the pool and calculate the pool money.
- Show the flop cards and receive decisions from players before the turn card (fourth shared card) until no more bets.
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- Show the winner according to their hand card power and assign the pool money to the winner(s).
- The hand power system is used to compare the hand card power. Hand power is followed by the following order from strongest to weakest: Straight Flush > Four of a kind > Full House > Flush > Straight > Tree of a kind > Two Pairs > One Pair > High Card

To see more details about game program structure, please refer to **section 3.1**. To know how to **run** the game system, please refer to **3.2**

2.2 AI System - Haoze He

Haoze He takes charge of the AI systems. AI systems are built based on the game system mentioned in section 2.1. The program contains multiple numbers of AI. AI can receive cards from the game system, evaluate the card power, predict what cards opponents have according to opponent betting decision history, and make betting decisions by themselves. The decisions will be returned to the game system as human players do. In the program, Haoze designed three difficulty Settings, each difficulty setting contains different AIs which have different decision models and prediction models. To be specific, all the AIs are listed below:

- **Easy Mode:** 1. Simple Bluff AI Strategy; 2. Simple Normal AI Strategy;
- **Middle Mode:** 3. Middle Bluff Strategy; 4. Aggressive Bluff AI Strategy; 5. Conservative Bluff AI Strategy 6. Middle Normal AI Strategy;
- **Hard Mode:** 7. Hard Aggresive Mix AI strategy; 8. Hard Conservative Mix AI Strategy;

To see more details about AI algorithms and AI program structure, please refer to **section 3.2**.

2.3 Backend System - Lin Yuan

The cloud server will interact with a cloud database and the front end UI. Our program is a registration-based system. In other words, each user will register an account and we will create a profile corresponding to that user into the database. Such profile should includes information like: past game history, current chips left, etc. User should have access to that information from the front-end UI.

Also, backend system will supports the communication work among players. Texas hold 'em is a multi-player game. Thus, real-time data exchange is also supported by backend server.

2.4 Frontend System - Xinyu Zhang

In order to control and present all the process we have in Texas hold 'em like the ability to check, bet, call, check, raise, or fold, we develop a interactive UI to let user better interacting with the game. User will see all the three stages "Flop, Turn and River" in the interface. Before every new hand begins, two players at the table will be obligated to post small and big blinds and one player will be the dealer for this round. We desired to bring the user an intuitive and immersive experience through a life-like and clean interface.

3 Methodology and Work Distribution

3.1 AI System - Haoze He

3.1.1 Program Structure

Each AI system will maintain prediction models which will be trained using the betting history of other players. AI system will generate prediction model for each opponent. Using prediction models for opponents, AI system will analysis what cards other players have according to their betting and history. Moreover, Each worker will maintain a local model to calculate the probability of wining, which will lead to next movement. Since our program provide multiple options of AI with different card play strategy, movement models in different AI will be different. The movement models will calculate the likely probability distribution for their own cards using the evaluation system. The structure of AI system can be found in Figure 1

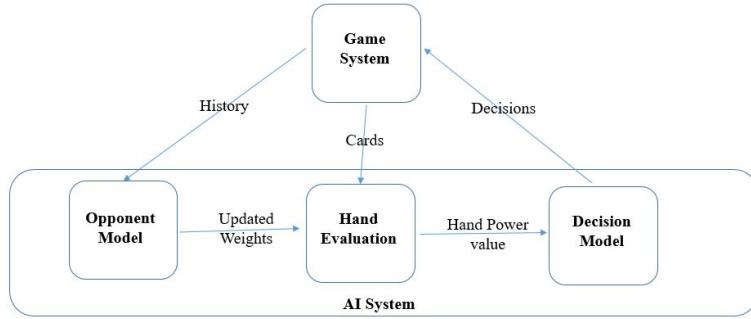


Figure 1: Structure of AI system.

3.1.2 How to Run the AI Simulation and Game system?

I include a **video** in the submission to present how the program works. You can also run **main.java.com.example.javaproject.AI.Play.java** to run the whole game system and AI competition simulation.

3.1.3 AI algorithm

In the following, I present the AI algorithms for AI systems. The algorithm for AI system are based on Algorithm 1, 2, and 3. Threshold parameters, opponent prediction models, and history maintain are different for different AI models.

3.2 Game System - Haoze He

3.2.1 Program Structure

Haoze build a game system which implements all the game logic and can generated AI easily. The system structure can be found in Figure 2.

In the game system, the **play** function will tell the system all the initial information including number of human player, number of AI player, AI mode(easy, middle, hard), initial

Algorithm 1 Hand Strength Calculation

```
1: winNum, tiedNum, lossNum = 0
2: ourrank = Rank(ourcards, boardcards)
3: while caseCards in boardcards do
4:   opporank = Rank(oppocards, caseCards)
5:   if ourrank > opprank then
6:     winNum += 1
7:   else if ourrank > opprank then
8:     tieNum += 1
9:   else
10:    lossNum += 1
11:   end if
12: end while
13: handstrength = (winNum + tiedNum/2)/(winNum+tieNum+lossNum)
```

Algorithm 2 Pre-flop Betting Stategy

```
1: threshold(strategy) = percentageOfWins * (1 + position/(2 × numberOf players))
2: if position > 2 and percentageOfW ins < 0.3 then
3:   Return FOLD
4: end if
5: if threshold > 0.5 then
6:   X = (threshold - 0.5)/0.6
7:   AMOUNT =  $e^{X^1}$  * MoneyInHand
8:   Return Raise and AMOUNT
9: else if threshold < 0.5 and threshold > 0.25 then
10:  Return Call
11: else
12:  Return Fold
13: end if
```

Algorithm 3 Post-flop Betting Stategy (for Flop cards, turn cards, and river cards)

```
1: EHS = HSn + (1 - HSn) × PPOT, HSn = Hand Strength
2: if EHS > 0.8 then
3:   Return Raise and Amount
4: else if EHS > 0.4 then
5:   Return Call
6: else
7:   Return Fold
8: end if
```

money, big blind, and small blind. Play function will create **GameProperties**, which will generate **playerControl** according to the given information. As for human player, the **playerControl** will receive the decisions made by human and give it to the system. As for AI players, the **playerControl** will generate **AIPPlayControl** which will make decisions according to AI systems. All the decisions will be provided to the game systems.

Meanwhile, the **play** function will also generate **PokerControl** function for each game.

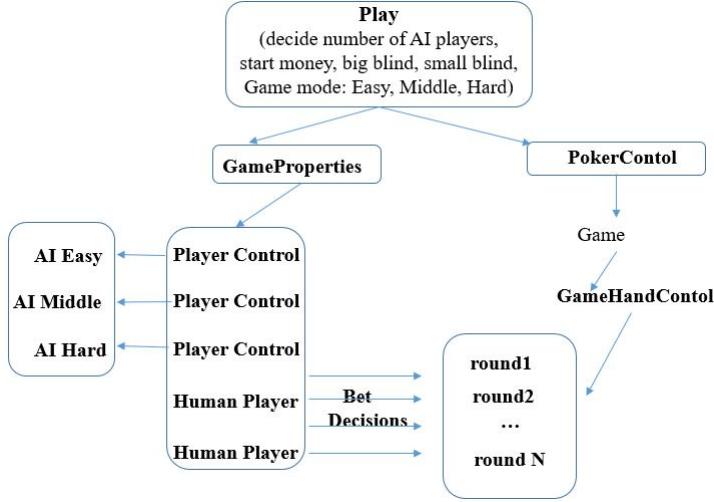


Figure 2: Structure of game system.

PokerControl will include **GameHandControl**, each **GameHandControl** will create multiple rounds for a single game hand. Every **PlayerControl** need to provide decisions in each round.

3.3 Frontend System - Xinyu Zhang

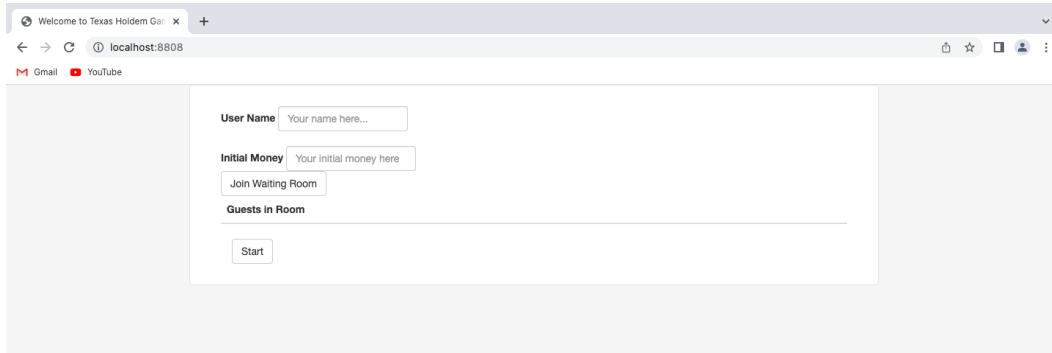
We will use JavaScript to build our user interfaces. After importing components like cards and players, create an HTML page with CSS to add images, fonts, and files, then convert the existing Web pages into React components to Render. We will use HTTPS in development and inject data from the server into the page. To integrate the web application with the back end, we create views and map them to URLs, via API calls the request will be sent to the back end.

3.4 Backend-System - Lin Yuan

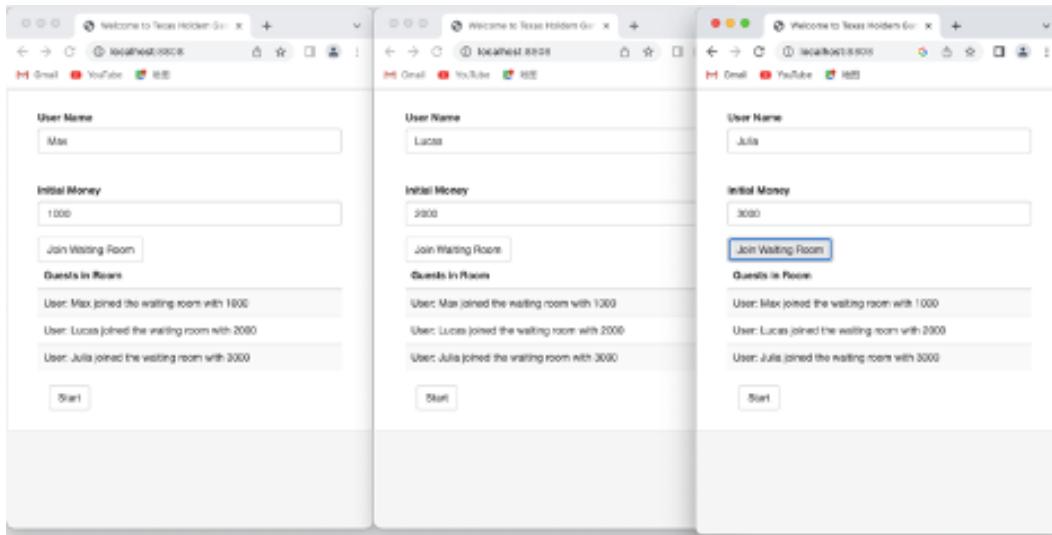
Particularly, we will use a cloud service provided by a major cloud computing platform such as AWS. In our EC2 server, we will use modern Java backend frameworks such as Springboot to develop our services. There are two major functions. The first one is enabled real-time communication between players, and the second one is maintain user informations. For the database, we will use a SQL database and use JDBC to support our interaction between server and database. In the database, we should maintain at least two tables that records all users' info and games' info.

4 Login Page

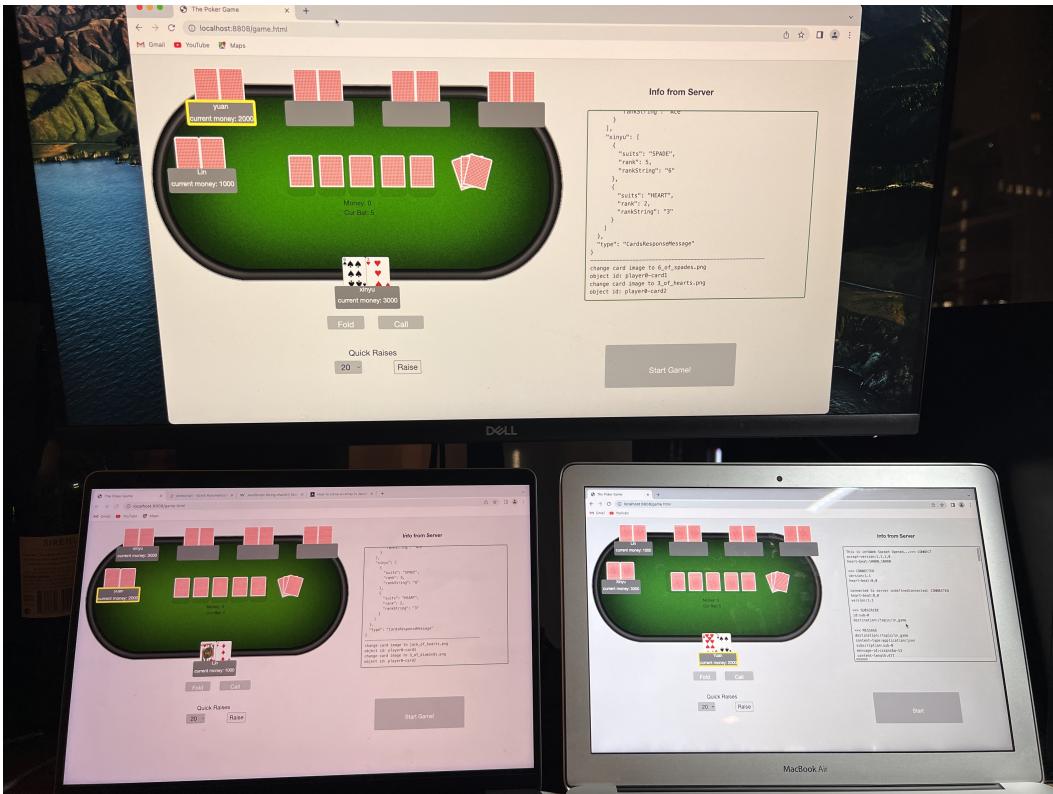
4.1 Welcome to Texas Holdem Game



- 4.2 Enter player's name in "User Name" and the Bank roll in "Initial Money". Every player will click the "Join Waiting Room" button to stay in waiting line for the game. All user name and their bank roll will display under "Guests in Room".



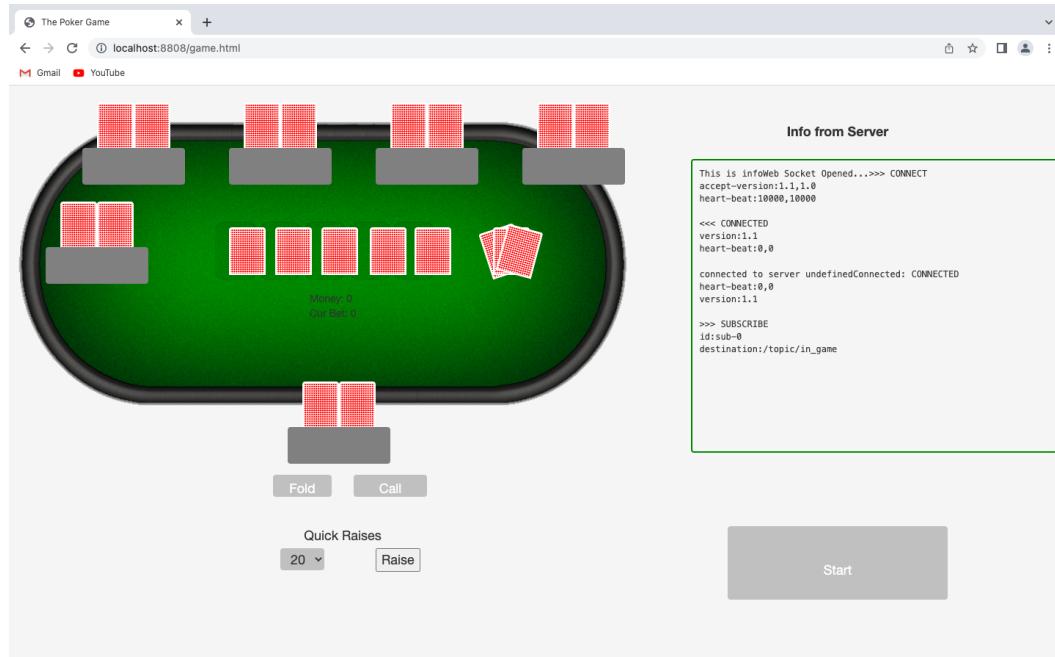
4.3 As long as one of the players click the button “Start”, the game will start and all user will be in the poker game room at the same time.



5 Poker Game Page

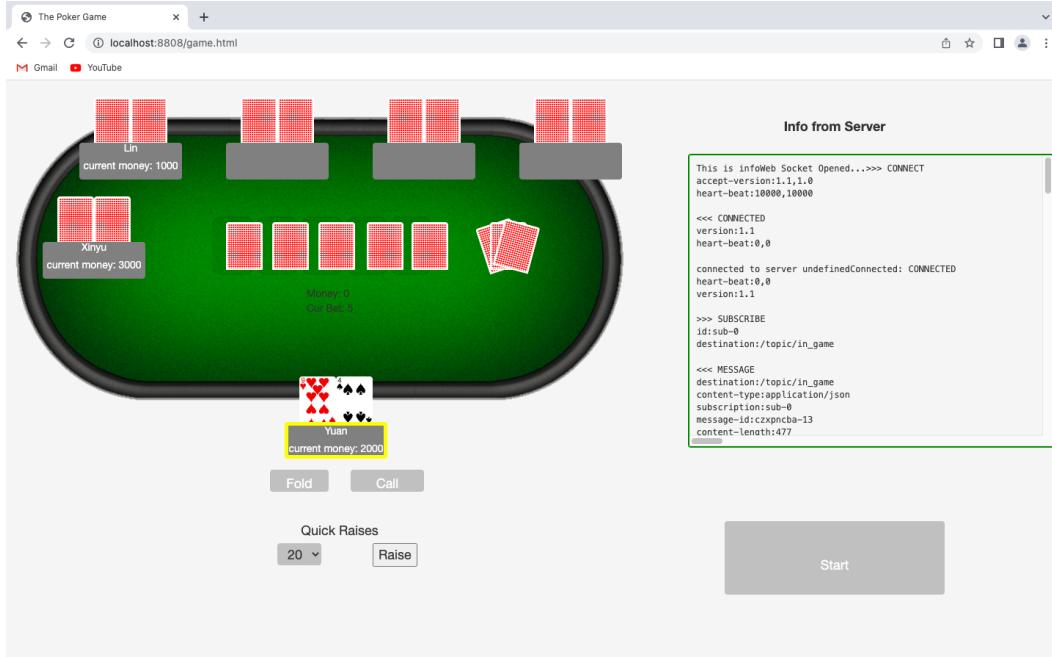
5.1 Board

- 5.1.1 Click “Start” on the right bottom, the game will start, and each player’s name will be display under their seats.



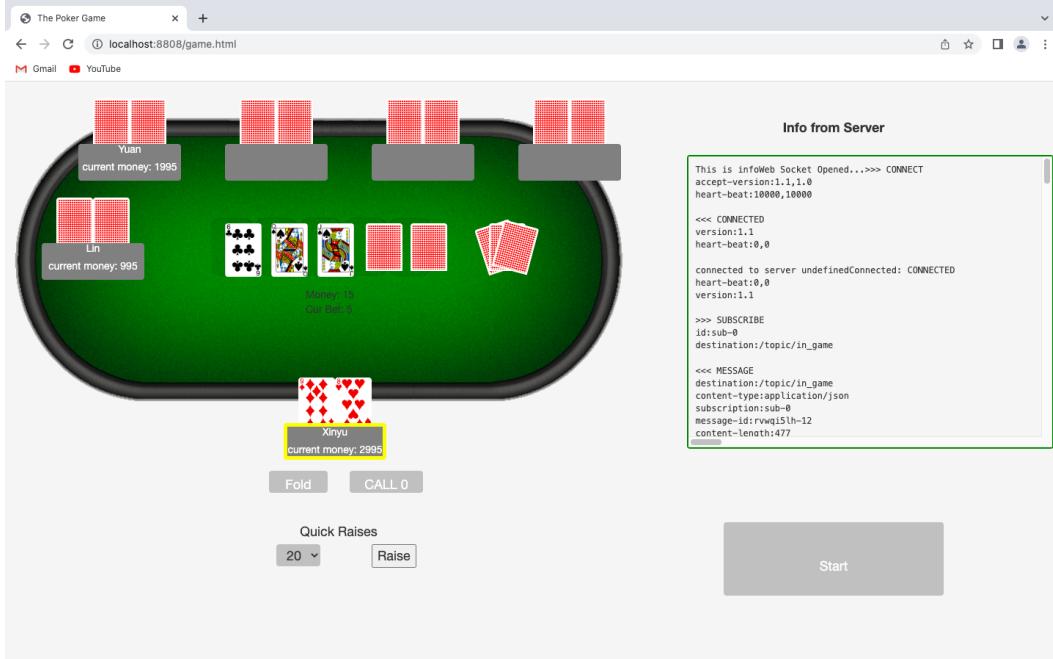
5.2 Player

5.2.1 After all player join the poker game room, each player is dealt two cards face down (the 'hole cards').



5.2.2 The player with yellow highlight on is the current player who is making the decision. There are the three options that a player can choose.

- Call: match the amount of the big blind
- Raise: increase the bet within the specific limits of the game
- Fold: throw the hand away



References

- [1] Michael Bowling, Neil Burch, Michael Johanson, and Oskari Tammelin. Heads-up limit hold'em poker is solved. *Science*, 347(6218):145–149, 2015.
- [2] Wikipedia. Texas hold 'em, Nov 2022. URL: https://en.wikipedia.org/wiki/Texas_hold_%27em.