6644 Simulation Project: Blackjack

Yuxi Chen

Abstract

The goal of this project is to create a simulation using variations of known Blackjack strategies to optimize player win rate. To find the optimal win rate, I implemented two different simulations that will be ran using variations of the basic soft and hard strategy. The hard strategy set the Ace to a value of 1 and the soft strategy has a flexible Ace value of either 1 or 11. For a single deck Blackjack game with a stand limit of 17, simulation one uses the soft strategy and has a win rate of 42.74%. Simulation two uses the hard strategy and has a win rate of 39.76%.

Background and Objectives

Blackjack Gameplay

In Blackjack, decks used contain the standard 52 cards consisting of four suites and thirteen cards per suite ranging from A, J, Q, K, and 1-10. Where Aces have a value of 1 or 11 and face cards have a value of 10. A game can contain anywhere between one to eight decks, the greater the number of decks used, the higher the win rate for the house.

The game starts when each player is dealt one card face up and the dealer is dealt one card face down. This is followed by a second card dealt face up for both player and dealer. The player then has the option to “Stand” or “Hit”. If the player chooses to “Hit”, then they will be dealt another card. The player can continue to “Hit” until the sum of cards in hand is equal to or less than 21. If the sum of the cards in hand is greater than 21, then the player “Busts” or loses the round. If the player chooses to “Stand”, then they will not be dealt any more cards.

The goal of the game is to reach a total value of 21 from the sum of cards in hand or have a higher total value than the sum of the dealer’s hand.

Simulation Objective

The average player win rate in Blackjack can be as high as 42.22%, with the average house win rate at 49.10% and average push rate at 8.48% (Blake, 2021).

The objective of this project is to simulate a Blackjack game to reach the average win rate of approximately 42% or higher. In this Blackjack project a simulation of a single deck game will used with the soft and hard strategies. Each round will consist of cards dealt to a single player and dealer.

Code

The following simulation was written using Python 3 via Visual Studio IDE. The code can be found in attached zip file. The zip file includes the following: deck.py, player.py, simulation.py, READ_ME.txt.

The simulation uses player class to determine the cards in player hand and total value of player hand. The deck class sets up the game deck, deals the card and determines the card value.

The code uses the following libraries: random, pandas, and matplotlib. Simulation one is defined by **sim_one**() and simulation two is defined by **sim_two()**. The simulation is repeated for 20,000 rounds indicated by the variable, **n**. The player and house are each dealt two initial cards. The player then has the decision whether to hit based on the current value of cards at hand. Loops and conditionals are used to determine when the player should hit or stand.

The result is then determined by comparing the **player.total** to the **house.total**, The result of each round is then recorded into the variables: **player_win**, **push** or **house_win**. The total of each simulation is then calculated to find the outcome rate.

Findings

Simulation one: Soft Strategy

All Aces can have a value of either 1 or 11, dependent on the current sum value of cards in hand. Repeat simulation using different standing limits from 15 to 19.

The player hits:

- Hand total is 17 or less.
- Hand total is 18 and dealer 2nd card is 3, 4, 5, 6, 9, 10, J, Q, K, A

The player stands:

- Hand total is 18 and dealer 2nd card is 2, 7, 8
- Hand total is 19 or greater

Using 17 as the stand limit as the baseline, the win rate for the soft strategy is 42.74%. At limit 16, the win rate of 43.34% and push rate of 9.88% are both higher indicating that setting the limit to 16 is the most effective in soft strategy to decrease the win rate of the house. At limit 19, the win rate of 36.24 is the lowest.

Simulation two: Hard Strategy

The player's Ace is always 1. Dealer's Ace can have value of either 1 or 11. Repeat simulation using different standing limits from 15 to 19.

The player hits:

- Hand total is 11 or less
- Hand total is 12 to 16 and dealer has 7, 8, 9, 10, J, Q, K, A

The player stands:

- Hand total is 12 to 16 and dealer has 2, 3, 4, 5, 6
- Hand total is 17 or greater

Using 17 as the stand limit as the baseline, the win rate for the hard strategy is 39.76% At limit 15, the win rate of 41.05% and push rate of 9.74% are both higher indicating that setting the limit to 15 is the most effective in hard strategy to decrease the win rate of the house. At limit 19, the win rate of 32.72 is the lowest.

Conclusion

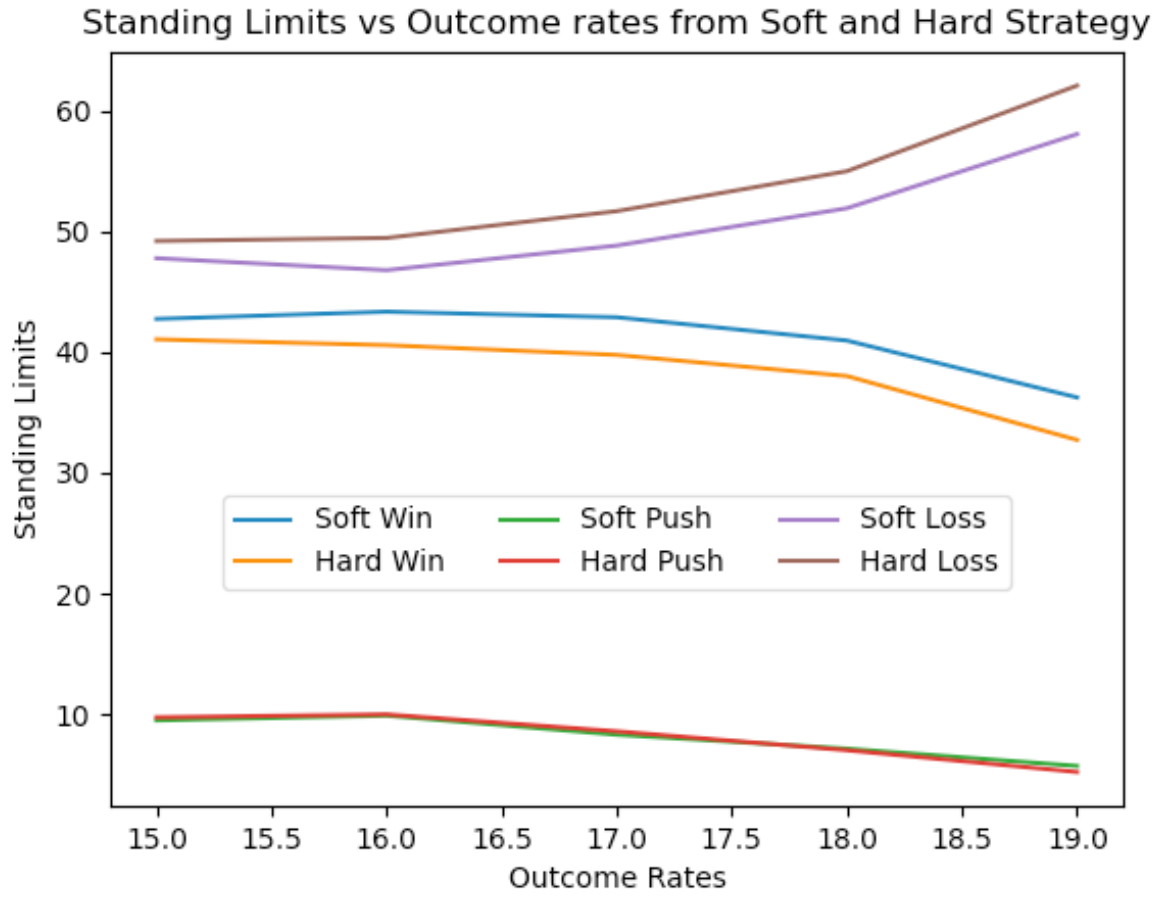
From this simulation, I learned about the various strategies used in Blackjack. Using the strategies from this simulation the best play style is the soft strategy as it had the highest win rate in a one versus one game. For future Blackjack simulations, I want to include more players and implement a starting wager to simulate a real game play. In doing so, I can also expand the types of strategies including splitting hands, doubling down or insurance on dealer blackjack. With these strategies I can calculate the amount of over money gained or lost over an X number of rounds. In real life applications, casinos typically use more than one deck, which increases the odds of house winning, and the deck is not shuffled each round. I want to explore outcome rates affected by the number of decks and how the outcome is affected by the shuffle rate. As the player utilizes different strategies, their win rate will increase by making the optimal next decision.

Appendix

Below highlights the code to generate the results from the simulation and output table/graph.

Limit Value	Soft Win	Hard Win	Soft Push	Hard Push	Soft Loss	Hard Loss
15	42.74	41.05	9.49	9.74	47.77	49.20
16	43.34	40.57	9.88	9.98	46.78	49.45
17	42.88	39.76	8.30	8.58	48.82	51.67
18	40.95	38.01	7.14	7.01	51.91	54.98
19	36.24	32.72	5.71	5.21	58.05	62.07

```
fig1 = plt.plot(sim_results)
plt.legend(['Soft Win', 'Hard Win', 'Soft Push', 'Hard Push', 'Soft Loss', 'Hard Loss'],
           loc='center', bbox_to_anchor=(0.5, 0.35),ncol=3)
plt.title('Standing Limits vs Outcome rates from Soft and Hard Strategy')
plt.xlabel('Outcome Rates')
plt.ylabel('Standing Limits')
plt.show()
```



References

1. Blake, M. (2021, December 1). *Blackjack Odds & House Edge explained*. Blackjack Odds, Probability & House Edge Explained. Retrieved December 2, 2022, from https://www.onlinegambling.com/blackjack/odds/

2. Jenson, K. P. (204AD). *The Expected Value of an Advantage Blackjack player* . Retrieved December 3, 2022, from https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1528&context=gradreports