Investigation into the Impact of Playing Strategy on Simulated Blackjack Outcomes

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Abstract

The impact of adding additional blackjack strategies on the player's simulated winning percentage is modelled in python and investigated. The simulation showed high variability in winning percentage when a lower number of trials are used. The simulated winning percentage eventually reaches a steady state after 40,000 hands are played where only a small amount of variability is seen. A basic strategy which includes hitting when the player's card count is less than 17 had a steady-state simulated winning percentage of 41.5%, 1.5 % less than the steady-state simulated winning percentage when more advanced blackjack strategies are used. Future work, such as adding additional strategies into the simulated, were suggested.

Background and Description of the Problem

Blackjack is a game of strategy and chance that requires a player to take appropriate actions depending on the cards they are dealt. Doing so can assist a player in winning a higher percentage of games in the long run resulting in more money in the player's pocket. In this project we tackle the impact implementing additional blackjack strategies has on the probability of a player winning the hand.

The game of blackjack is a simple game where the goal is to beat the dealer by getting a card count close to 21 without going over 21. A game starts by each player and the dealer being dealt two cards. The dealer reveals one of their cards allowing each player to make an educated decision as to hit (request another card) or stay. The basic strategy of blackjack is to only request a new card if the total of a player's cards is less than 17. The card count is determined by the value shown on the card. Cards that show a number 2 through 10 are counted as the number shown, face cards (i.e., Jack, Queen, and King) hold a value of 10, and aces can either be 1 or 11 depending on the player or dealer's current situation. If a player is dealt a card with a value of 10 (i.e., a 10 or a face card) and an ace it said to be a "Blackjack" and the player automatically wins the hand.

In blackjack there are controlled variables that we cannot modify. For instance, the deck must consist of 52 cards that are drawn without replacement. It is also assumed the deck is shuffled adequately so that the odds of drawing each card in the deck are equal and do not contain bias. In the current project we are assuming the player is not "counting cards", if the reader is interested in learning about how this method can improve a player's return please reference the 2008 movie, 21. Although these assumptions lower the player's overall odds of winning there are methods that can be used to improve a player's odds.

There are legal methods to increase the player's odds at winning. For instance, Figure 1 shows a table of the suggested actions depending on the player's cards and the dealer card visible to the table. The basic strategy suggests a player should hit if the total of their cards is less than 17 and stay if the total of the cards is 17 or greater. However, it is clear there are more advanced strategies that are dependent on the situation at the table. An example is that the player should stay if the total of their cards is 13, 14, 15, 16 and the dealer's visible card is between 2 and 6. Further there are times when a player can "split" their cards if dealt two of the same cards. Doing so allows a player to play two hands which can increase their odds of winning. In the present study we will take a subset of these more advanced strategies and investigate their impact on the simulated winning percentage.

	2	3	4	5	6	7	8	9	10	A
5-7	H	H	H	H	H	H	H	H	H	H
8	H	H	H	Dh	Dh	H	H	H	H	H
9	Dh	Dh	Dh	Dh	Dh	H	H	H	H	H
10	Dh	Dh	Dh	Dh	Dh	Dh	Dh	Dh	H	H
11	Dh	Dh	Dh	Dh	Dh	Dh	Dh	Dh	Dh	Dh
12	H	H	S	S	S	H	H	H	H	H
13	S	S	S	S	S	H	H	H	H	H
14	S	S	S	S	S	H	H	H	H	H
15	S	S	S	S	S	H	H	H	H	H
16	S	S	S	S	S	H	H	H	Suh	Suh
17	S	S	S	S	S	S	S	S	S	S
18	S	S	S	S	S	S	S	S	S	S
19	S	S	S	S	S	S	S	S	S	S
20	S	S	S	S	S	S	S	S	S	S
21	S	S	S	S	S	S	S	S	S	S
A-2	H	H	Dh	Dh	Dh	H	H	H	H	H
A-3	H	H	Dh	Dh	Dh	H	H	H	H	H
A-4	H	H	Dh	Dh	Dh	H	H	H	H	H
A-5	H	H	Dh	Dh	Dh	H	H	H	H	H
A-6	Dh	Dh	Dh	Dh	Dh	H	H	H	H	H
A-7	S	Ds	Ds	Ds	Ds	S	S	H	H	S
A-8	S	S	S	S	Ds	S	S	S	S	S
A-9	S	S	S	S	S	S	S	S	S	S
A-10	S	S	S	S	S	S	S	S	S	S
2-2	P	P	P	P	P	P	H	H	H	H
3-3	P	P	P	P	P	P	P	H	H	H
4-4	H	H	P	P	P	H	H	H	H	H
5-5	Dh	Dh	Dh	Dh	Dh	Dh	Dh	Dh	H	H
6-6	P	P	P	P	P	H	H	H	H	H
7-7	P	P	P	P	P	P	P	H	Sus	H
8-8	P	P	P	P	P	P	P	P	P	P
9-9	P	P	P	P	P	S	P	P	S	S
10-10	S	S	S	S	S	S	S	S	S	S
A-A	P	P	P	P	P	P	P	P	P	P

S17 =	Dealer stands on soft 17
DAS =	Doubling down after pair splitting allowed
H =	Hit
S =	Stand
D =	Double
Dh =	Double if allowed; otherwise Hit
Ds =	Double if allowed; otherwise Stand
P =	Split
Su =	Surrender
Suh =	Surrender if allowed; otherwise Hit
Sus =	Surrender if allowed; otherwise Stand

Figure 1. Table of blackjack strategies. Figure taken from [1].

In this study I wanted to ensure enough of the more advanced strategies were used to obtain a statistically relevant result compared to the basic strategy while not inducing unnecessary complex code. The additional strategies chosen are shown below.

- Hit if a soft 18 (A + 7) and dealer's visible card is 9, 10, Jack, Queen, King, or Ace
- Stay if the total of their cards is 13, 14, 15, 16 and the dealer's visible card is between 2 and 6

The next step in the study was to select a coding language to investigate the problem. Python was chosen because of the flexibility of the language while also offering a variety of packages to induce randomness in the simulation. In the current project random, numpy, and pandas were used to initialize the simulation and collect data. All source code and simulation data can be found in the Github repository located here.

Main Findings

A plot showing all simulated results can be seen in Figure 2. The data points labeled as red squares denote test cases of the basic strategy (i.e., hit while count of cards is less than 17, otherwise stay) while black circles show a more advanced strategy (i.e., using table situation to inform player behavior).
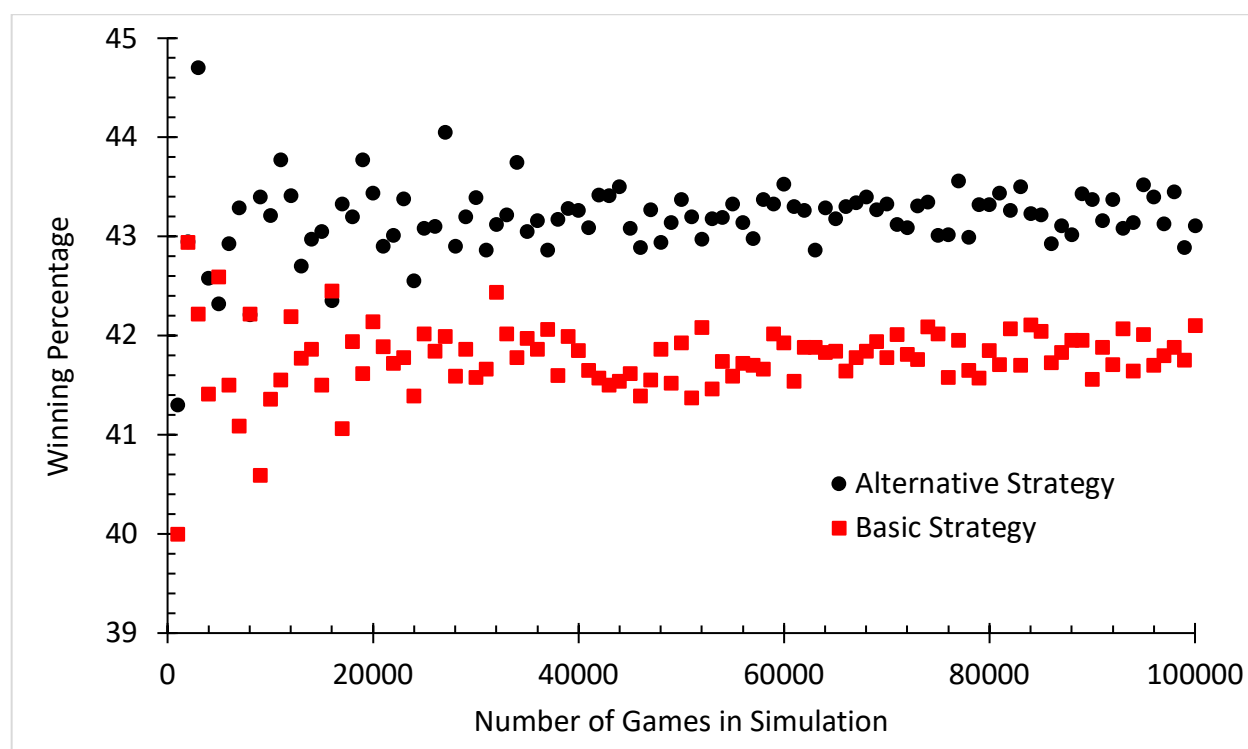

Figure 2. A plot showing the average winning percentage as a function of number of games in the simulation for each blackjack strategy.

The basic strategy achieves a winning percentage around 41.5% and exhibits heteroskedastic behavior over the number of games in the simulation. As expected, the variability in the model output is high when a lower number of simulations are run. The

variability decreases and eventually achieves steady state after around 40,000 simulation runs. This result is expected due to the law of large numbers which suggests the sample mean converges to the expected mean after sufficient trials.

The advanced strategy achieves a winning percentage around 43% and exhibits the same variability as the basic strategy at lower number of trial runs. The advanced strategy seems to reach steady state after the same number of trials as the basic strategy. Again, this result is expected because of the law of large numbers.

The more advanced strategy has a higher winning percentage than the basic strategy. This is evidenced by the steady state winning percentage average for the advanced strategy being higher (~1.5 %) than the basic strategy. This result is expected. The strategies and methods to increase odds in blackjack have been widely reported. Baldwin et al. [2] showed in 1956 that there are mathematical methods that can be used to improve a player's chances of winning. Further, the numerous websites that write about blackjack (e.g., www.888casino.com, www.blackjackapprenticeship.com, https://blog.prepscholar.com/blackjack-strategy) speaks to the impact simple decisions can have on the player's odds of winning.

In future work, it is pertinent to include other permutations of proposed blackjack strategies into the code. Doing so could yield interesting results on what a player "should" do in a particular situation. The eventual goal is to optimize the blackjack equation so a player can choose a route that is backed in data and not chance.

Conclusions

- The win percentage was simulated to be around 41.5% using the simplest blackjack strategy of hitting if the player's card total is less than 17 and staying if greater than or equal to 17.
- By introducing two commonly used strategies (i.e., stay if card total is 12, 13, 14, 15 or 16 if dealer fact card is 2 – 6 and hitting on a soft 18 and dealer 9, 10, Jack, Queen, or King) the simulated winning percentage increased to around 43%
- Through introducing the alternative strategies, the chances of winning showed a significant increase although the early simulation variability remained.
- Future work includes adding additional strategies to investigate the impact on the simulated winning percentage.

References

[1]   "Blackjack Charts." https://www.888casino.com/blog/blackjack-strategy-guide/blackjack-charts#single-deck-charts.

[2]   R. R. Baldwin, W. E. Cantey, H. Maisel, and P. James, "The Optimum Strategy in Blackjack," vol. 51, no. 275, pp. 429–439, 1956.