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Under 21

Analyzing the various strategies used to enhance the probability of winning Blackjack

COSMOS

Abstract

There are different strategies in Blackjack that players claim can give them the edge over the dealer. In our project, we simulated Blackjack games using Python in order to determine what the best strategy truly is. We tested for the best value for the player to stand at (1-21) in order to have the highest probability of winning, as well as how using card counting affects the amount of money a player wins. We also included various options such as adding more players and decks. Our results show that 14 is the best value to stand at whether you are using or not using card counting, but the player only wins roughly 42.5% of the time. This strategy that we have discovered could help to optimize a player's chances of winning. However, we have found that the player will ultimately always lose money against the dealer when playing a large amount of games and betting without considering the dealer's shown card.

Background

Blackjack, also known as "twenty-one," is a popular card game that dates back to the seventeenth century and is the single most played casino banking game in the world. It involves players who bet against a dealer on having the higher score without exceeding twenty-one or "busting." Because the house has an advantage, players heavily depend on various strategies such as standing at a certain value or counting cards to win.

According to the law of large numbers, frequencies of events with the same likelihood of occurrence even out as the number of instances increase. In other words, when testing which values to stand at for Blackjack, simulating the game a large number of times for each value allowed us to accurately determine the chance of winning when standing at each specific value.

Hypothesis

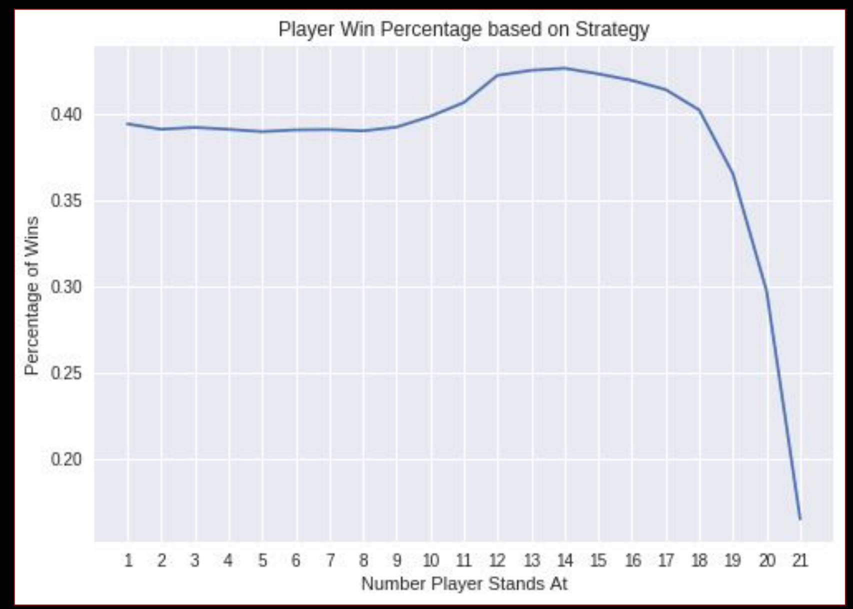
Since the dealers at casinos stand on seventeen or greater, we inferred that standing on seventeen or above would be the most optimal strategy for Blackjack because casinos would not adopt a strategy that causes them to lose money. Additionally, because card counting is known to be an effective strategy to increase chances of winning, we predicted that it would greatly increase the amount of money won.

Methods

```
#gives house and player both initial two cards
card = deckindex.pop(random.randint(0,len(deckindex)-1))
playerValue += deck[card]
if deck[card] == 11:
  countPlayerAce += 1
houseCard = deck[deckindex.pop(random.randint(0,len(deckindex)-1))]
houseValue += houseCard
if houseCard == 11:
  countHouseAce += 1
card = deckindex.pop(random.randint(0,len(deckindex)-1))
playerValue += deck[card]
if deck[card] == 11:
  countPlayerAce += 1
houseCard = deck[deckindex.pop(random.randint(0,len(deckindex)-1))]
houseValue += houseCard
if houseCard == 11:
  countHouseAce += 1
#if you get 21 you win
if playerValue == 21:
  playerWin += 1
else:
  #both player and house take their turns hitting
  while (playerValue < n):
    add = deck[deckindex.pop(random.randint(0,len(deckindex)-1))]
    if add == 11:
      countPlayerAce += 1
    playerValue += add
    if playerValue > 21 and countPlayerAce > 0:
      playerValue -= 10
      countPlayerAce -= 1
  if houseValue == 21:
    houseWin += 1
  else:
    while (houseValue < 17):
      add = deck[deckindex.pop(random.randint(0,len(deckindex)-1))]
      if add == 11:
        countHouseAce += 1
      houseValue += add
      if houseValue > 21 and countHouseAce > 0:
        houseValue -= 10
        countHouseAce -= 1
    #checks whether there are ties or who wins
    if playerValue > 21:
      houseWin += 1
    elif houseValue > 21:
      playerWin +=1
    elif playerValue == houseValue:
      tie += 1
    else:
      if playerValue > houseValue:
        playerWin += 1
      else:
        houseWin += 1
  playerValueArray.append(playerValue)
  houseValueArray.append(houseValue)
print(playerWin + houseWin + tie)
print(str(n) + " Player Wins: " + str(1.0 * playerWin / loops))
return 1.0 * playerWin / loops, playerValueArray, houseValueArray
```

- First, we coded for the dealer to deal two cards each to both the player and himself.
- If the player reaches a total sum of 21 after the two cards are dealt to them, they automatically win.
- Next, we coded the player's turn. The player continues hitting until reaching a certain value.
- One challenge we encountered was the problem of the ace card. In our code, when the player draws an ace, 11 is automatically added the the player's total sum. The player's ace counter variable, which counts the number of aces that is used as 11, is also incremented by 1. When and if the player goes over 21, the code checks whether the player has an ace with the ace counter variable. If the player has an ace with a value of 11 when the player goes over 21, 10 is subtracted from the total sum of their cards. The ace counter variable is then decreased by 1.
- During the dealers turn, we coded it so that the dealer hits until the total sum was 17 or higher to simulate what happens in a casino. The rules with the ace that was applied to the player was applied to the dealer as well.
- After coding both the player and dealer's turns, we coded the win conditions. If the player's value is above 21, they lose. Else if the dealer's value is above 21, then the player wins. If neither of those conditions are true and the dealer and player ended their turns with the same sum, then it is a tie. If none of these three conditions are true, the code gives a win to whoever has the higher value since both numbers must be less than or equal to 21 and also different from one another.
- We compared the percentage of wins for the player and dealer to determine the best value to stand at.
- We created many versions such as having multiple decks, continuous shuffling, and betting with or without card counting. Each of the various graphs created with simulations shows something specific.

Data



Number to Stand At	Percentage of Wins
1	0.39404
2	0.39095
3	0.39202
4	0.39091
5	0.38958
6	0.39059
7	0.39077
8	0.39001
9	0.39221
10	0.3984
11	0.40643
12	0.42216
13	0.42508
14	**0.42627**
15	0.42302
16	0.41923
17	0.41392
18	0.40208
19	0.36524
20	0.2975
21	0.16534

Figure 1: The player win percentage after 100,000 games for each value the player can stand at in a full Blackjack game with 6 decks, and deck shuffling when the cards run out.

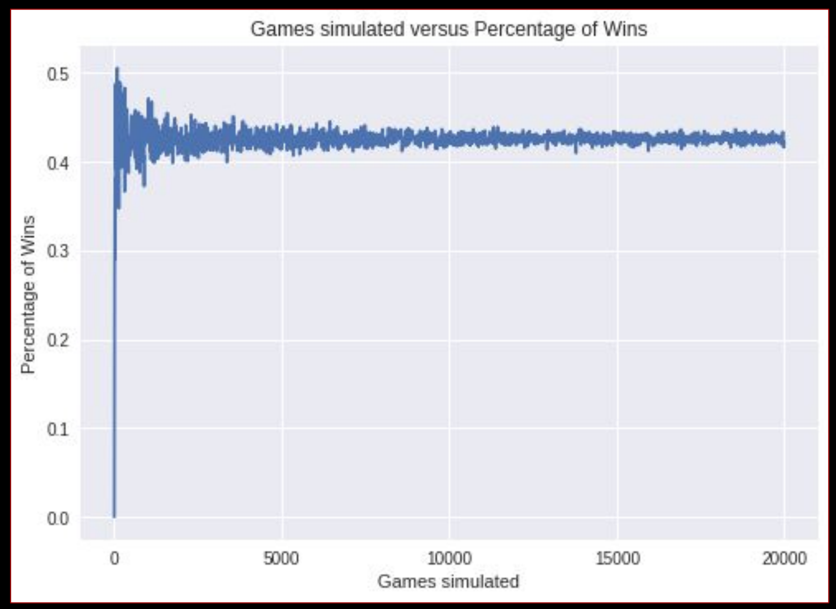


Figure 2: The percentage of wins of a player who stands at 14 based on number of games simulated (1 to 20000) converges to 42.5%, which shows that 100,000 simulated games is adequate to draw conclusions.

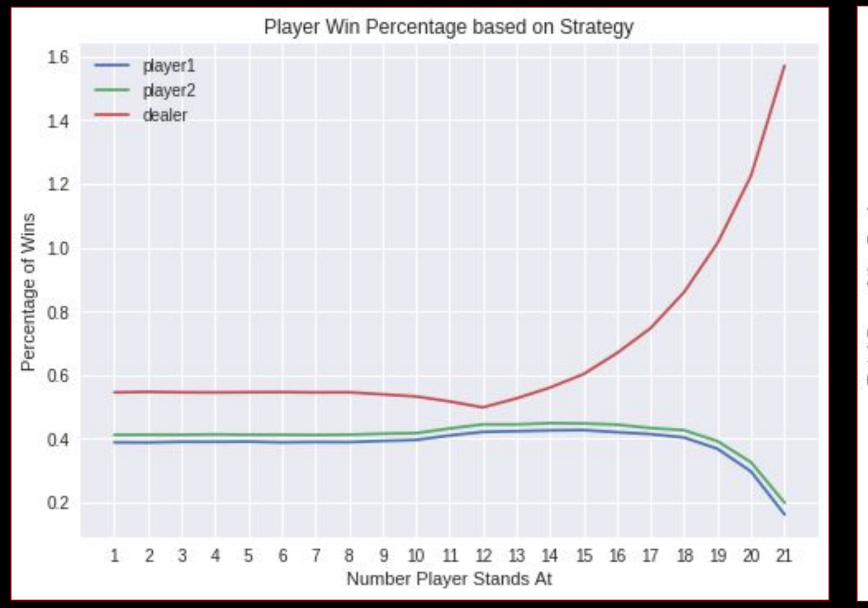


Figure 3: The percentage of wins for two players and the dealer based on what number the players stand at. It is apparent that the dealer always has an advantage.

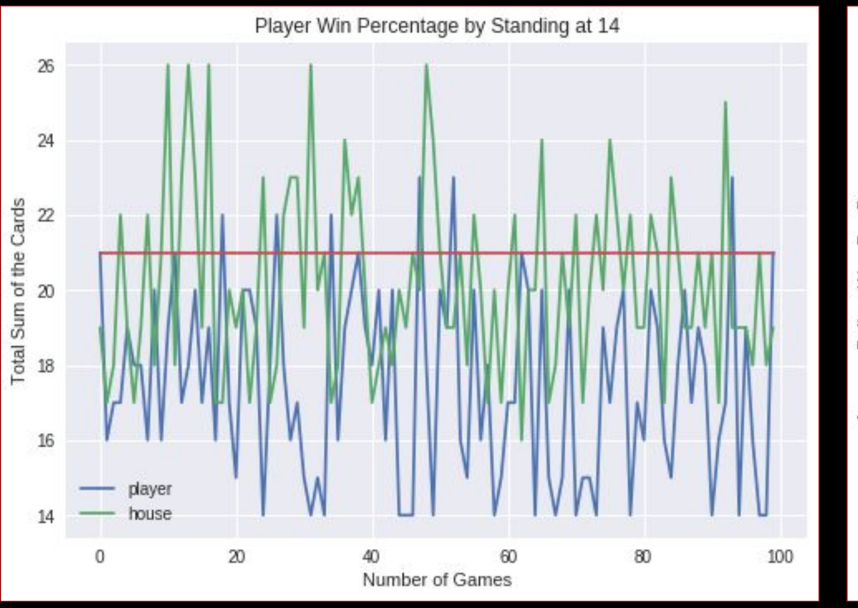


Figure 4: Total value of the player's cards who stands at 14 for 100 games and total value of the house's cards. This shows that the house frequently busts.

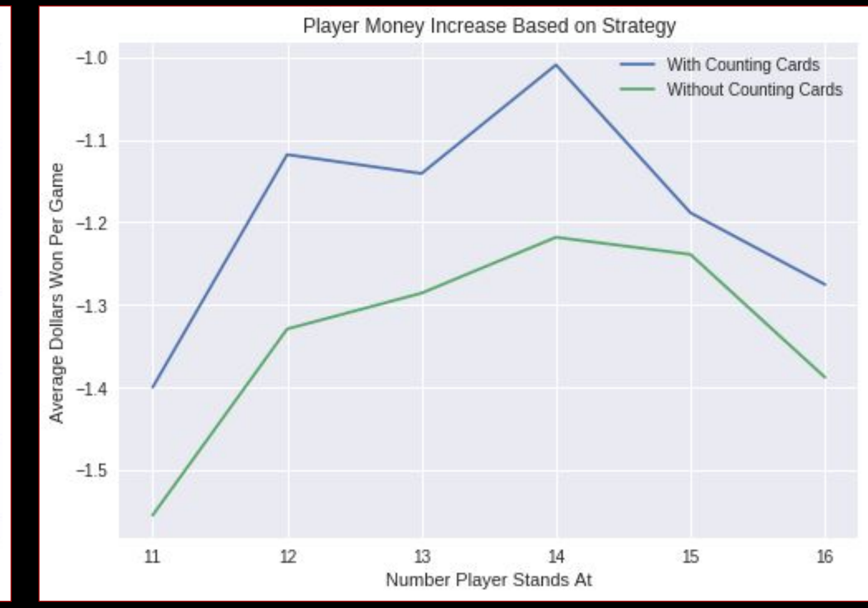


Figure 5: The amount of money a player standing at 14 wins on average per game with and without counting cards when the betting unit is 10 dollars.

Conclusion

After running numerous Blackjack simulations, we determined that the best number to stand at is 14 (Figure 1). We confirmed that 100,000 games was enough to draw this conclusion by finding the percentage of wins of a player who stands at 14 based on number of games simulated (1 to 20000), which converged to 42.5% (Figure 2). However, our data also shows that the dealer has a higher chance of winning regardless of what the player stands at (Figure 3). 14 is a surprising result since the house chooses to stand at 17; however, we noticed that when we simulated a large number of games, the dealer was likely to bust, which allowed the player, who stood at a value that was less prone to busting, to win (Figure 4). We also noticed that implementing card counting slightly increased the amount of money won per game, but the player still lost money on average (Figure 5). Including multiple players or decks to the game did not significantly change our results. We determined that the amount of games played changes the outcome. The player increases the chances of winning money if they play less games, but they also have the risk of losing more money.

Future Directions

In the future, we would look deeper into why casinos stand at 17 to better understand their strategy and echo it in our own. Additionally, we would test out another strategy that would take into account the value of the dealer's shown card before the player decides on whether to hit or not, rather than strictly hitting until they reach or exceed a specific value. This would likely lead to an increase in percentage of wins and amount of money won for a player who uses card counting.

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