Final Project: Let It Ride Computer GUI Game (Topic 11c)

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MATH 3808 A: Math Analy of Games of Chance

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Introduction

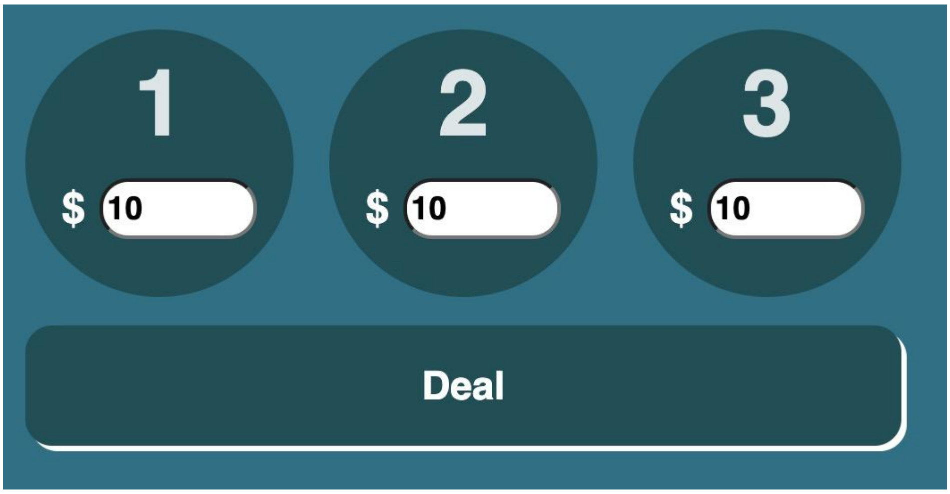
Welcome to the report on the LET IT RIDE casino game created by our team! This report provides an overview of our game, which is available on our GitHub repository (https://github.com/Karanpatel-15/Let-It-Ride) and can be played on our website (https://let-it-ride.vercel.app/).

Our team has developed an exciting and engaging version of the popular casino game, LET IT RIDE. In this report, we will discuss the key features of our game, including the rules, gameplay mechanics, and some more in-depth analysis into the game probability.

Game Rules

Let It Ride Poker is a modern take on traditional poker that involves five cards. Instead of competing against the dealer, players are pitted against a pay table. It is played with a standard deck of 52 cards.

Before being dealt any cards, the player must select an amount they want to wager which is to be distributed among three equal bets, which can vary from the minimum amount required by the casino to play to the maximum amount.

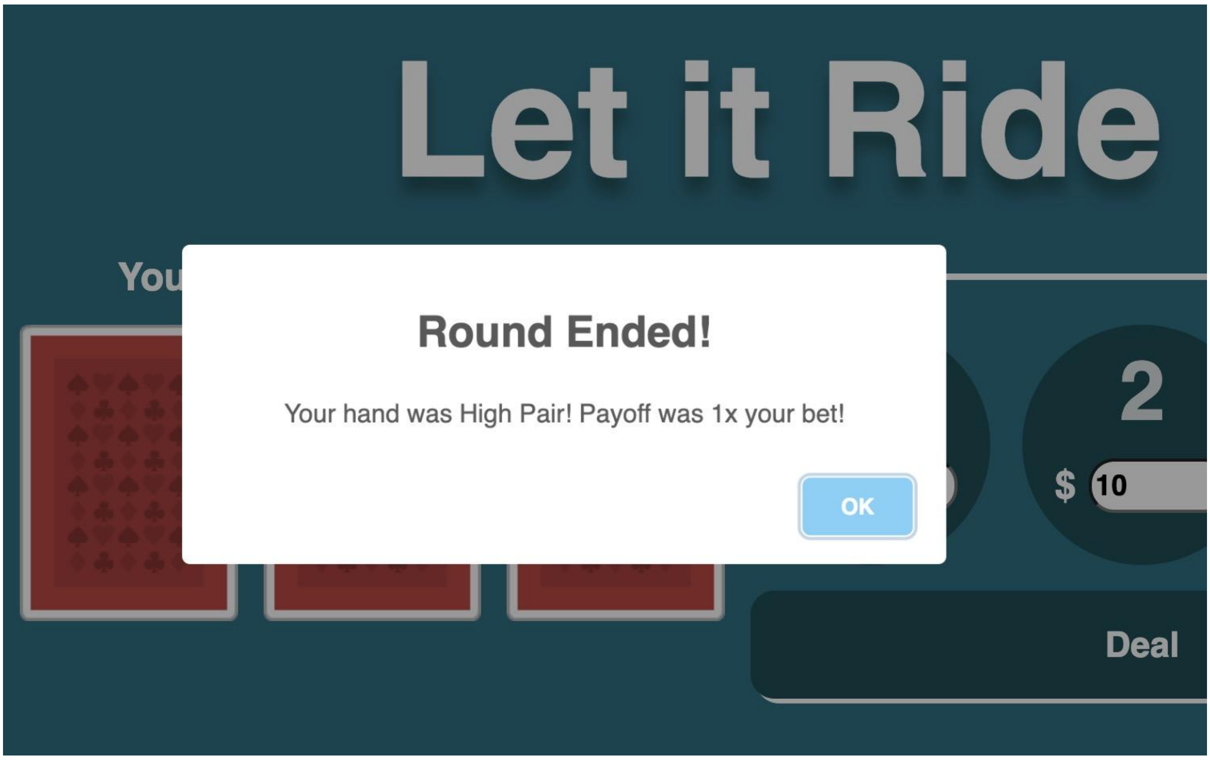


Once all the bets are secured, the player's three cards are dealt while the two extra community cards are found face down on the table. While the original base bet (bet #3) is already locked in, the player has an option to remove bet #1 if they feel like the three cards provided will not suffice.

After deciding whether to remove bet #1 or to wager it, the first community card is flipped over and displayed for the player to see. Here the player can make their next decision on whether to keep or remove bet #2 if they are not confident in their subset of 4-cards.

Finally, after deciding whether to remove bet #2 or to wager it, the second community card is then flipped over and displayed for the player to see.

Now there are no more wagers to be made as all the cards are in play and the payout tables for each bet can be seen below.



Paytable and Money tracker

Analysis Examples

Bet #3 Example: (Base Bet)

This bet is compulsory to play the game, there is no strategy involved since we do not know what any of our cards are. The player's expected value is that according to a 5-card poker hand.

First, we are going to look at the probabilities of each outcome from the payout table. This is done by taking all the possible numbers of hands of each payoff and dividing it by the total number of hands (52-choose-5) of a 5-card poker hand. It is recommended at starting at the highest rank and working down to easier account for probability overlap between events.

$$P(Royal\ Flush) = \frac{C_1^4 * C_5^5}{C_5^{52}} = \frac{4\ \#\ of\ hands}{2{,}598{,}960\ total\ \#\ of\ hands} = 0.0001539\%$$

When looking at the outcome of a straight flush, we want to remember not to include the Royal Flush since it is already accounted for in its own event. Therefore, we only do 9-choose-1 rather than the total 10-choose-1.

$$P(Straight\ Flush) = \frac{C_1^9 * C_1^4 * C_5^5}{C_5^{52}} = \frac{36\ \#\ of\ hands}{2{,}598{,}960\ total\ \#\ of\ hands} = 0.0013852\%$$

$$P(Four\ of\ a\ Kind) = \frac{C_1^{13} * C_4^4 * C_1^{12} * C_1^4}{C_5^{52}} = \frac{624\ \#\ of\ hands}{2{,}598{,}960\ total\ \#\ of\ hands} = 0.0240096\%$$

$$P(Full\ House) = \frac{C_1^{13} * C_3^4 * C_1^{12} * C_2^4}{C_5^{52}} = \frac{3{,}744\ \#\ of\ hands}{2{,}598{,}960\ total\ \#\ of\ hands} = 0.1440576\%$$

When calculating the Flush and Straight outcome probabilities, we know that there is overlap with the Royal Flush and Straight Flush outcomes. To account for each individual payout, we subtract each flush and straight outcomes by both the royal flush and straight flush number of hands.

$$P(Flush) = \frac{(C_1^4 * C_5^{13}) - (C_1^{10} * C_1^4 * C_5^5)}{C_5^{52}} = \frac{5{,}108\ \#\ of\ hands}{2{,}598{,}960\ total\ \#\ of\ hands} = 0.1965402\%$$

$$P(Straight) = \frac{[C_1^{10} * (C_1^4)^5] - (C_1^{10} * C_1^4 * C_5^5)}{C_5^{52}} = \frac{10{,}200\ \#\ of\ hands}{2{,}598{,}960\ total\ \#\ of\ hands} = 0.3924647\%$$

$$P(Three\ of\ a\ Kind) = \frac{C_1^{13} * C_3^4 * C_2^{12} * (C_1^4)^2}{C_5^{52}} = \frac{54{,}912\ \#\ of\ hands}{2{,}598{,}960\ total\ \#\ of\ hands} = 2.1128451\%$$

$$(Two\ Pair) = \frac{C_2^{13} * C_2^4 * C_2^4 * C_1^{11} * C_1^4}{C_5^{52}} = \frac{123{,}522\ \#\ of\ hands}{2{,}598{,}960\ total\ \#\ of\ hands} = 4.7539016\%$$

$$(High\ Pair\ \{10, J, Q, K, A\}) = \frac{C_1^5 * C_2^4 * C_3^{12} * (C_1^4)^3}{C_5^{52}} = \frac{422{,}400\ \#\ of\ hands}{2{,}598{,}960\ total\ \#\ of\ hands} = 16.2526549\%$$

Since the only event left is a lower than Pair 10, the sum of all the probability percentages (23.8780128%) can just be subtracted by 100% to get the outcome.

$$P(Lower\ than\ Pair\ 10) = 100\% - 23.8780128\% = 76.1219872\%$$

With the relative Payoff table, the player's EV for Bet #3 is:

$$\begin{aligned} EV(Player) = & -1(76.1219872\%) + 1(16.2526549\%) + 2(4.7539016\%) \\ & + 3(2.1128451\%) + 5(0.3924647\%) + 8(0.1965402\%) + 11(0.1440576\%) \\ & + 50(0.0240096\%) + 200(0.0013852\%) + 1000(0.0001539\%) \\ = & -0.372722951 \end{aligned}$$

This shows us the player's expected value going into a Let it Ride game not counting any additional bets they may make.

Bet #1 Example:

In this bet, 3 cards are already exposed where the player has the option to add in an extra bet based on the information given. The player's expected value is based on the 4th and 5th cards being drawn in relation to the 3 cards they already have set. In this example the player is drawn the subset that can be seen below.

$$Bet\ \#1\ Example\ Subset: \{3♥, 4♥, 5♠\}$$

Starting at the highest rank, we work our way down while remembering which events are possible based on the given subset. Again, we find the number of outcomes per given event, and divide it by the total number of outcomes (49-choose-2 since there are 49 cards remaining and 2 cards to pick) from drawing the last two cards.

$$P(Royal\ Flush) = 0\%$$

$$P(Straight\ Flush) = 0\%$$

$$P(Four\ of\ a\ Kind) = 0\%$$

$$P(Full\ House) = 0\%$$

$$P(Flush) = \frac{C_2^{10}}{C_2^{49}} = \frac{45\ \#\ of\ hands}{1176\ total\ \#\ of\ hands} = 3.8265306\%$$

$$P(Straight) = \frac{3(4)^2}{C_2^{49}} = \frac{48\ \#\ of\ hands}{1176\ total\ \#\ of\ hands} = 4.0816327\%$$

$$(Three\ of\ a\ Kind) = \frac{C_1^3 C_2^3}{C_2^{49}} = \frac{9\ \#\ of\ hands}{1176\ total\ \#\ of\ hands} = 0.7653061\%$$

$$(Two\ Pair) = \frac{C_2^3 * 3 * 3}{C_2^{49}} = \frac{27\ \#\ of\ hands}{1176\ total\ \#\ of\ hands} = 2.2959184\%$$

$$(High\ Pair\ \{10, J, Q, K, A\}) = \frac{5C_2^4}{C_2^{49}} = \frac{30\ \#\ of\ hands}{1176\ total\ \#\ of\ hands} = 2.5510204\%$$

Again, for the lower than 10 event, we take the sum of all event's probabilities and subtract it from 100%. Giving us:

$$P(Lower\ than\ Pair\ 10) = 100\% - 13.5204082\% = 86.4795918\%$$

Finally, the player's expected value on making a #1 Bet with the given subset can be computed as:

$$\begin{aligned} &EV(Player\ Bet\ \#1) \\ &\quad = -1(86.4795918\%) + 1(2.5510204\%) + 2(2.2959184\%) \\ &\quad + 3(0.7653061\%) + 5(4.0816327\%) + 8(3.8265306\%) = -0.26020408 \end{aligned}$$

In this scenario, the player should not ride given that their expected value is negative.

Bet #2 Example:

In this bet, 4 cards are already exposed where the player has the option to add in another extra bet based on the information given. The player's expected value is based on that final 5th card being drawn in relation to the 4 cards they already have set. In this example the player is drawn the subset that can be seen below.

$$Bet\ \#2\ Example\ Subset: \{4\clubsuit, 5\clubsuit, 6\clubsuit, 7\clubsuit\}$$

Starting at the highest rank, we work our way down while remembering which events are possible based on the given subset. Again, we find the number of outcomes per given event, and divide it by the total number of outcomes (the value is 48 since there are only that many cards remaining in the deck) from drawing the last card.

$$P(Royal\ Flush) = 0\%$$

Since all given cards in the subset are of the same suit (clubs), it is possible to get a straight flush if a 3 or 8 is drawn on the last card. However, they would have to be of the same suit giving only two hands.

$$P(Straight\ Flush) = \frac{2 * 1\ \#\ of\ hands}{48\ total\ \#\ of\ hands} = \frac{2}{48}$$

$$P(Four\ of\ a\ Kind) = 0\%$$

$$P(Full\ House) = 0\%$$

For both the straight and flush, we want to remember to not account for the straight flush event occurring. Therefore, for the flush event, we want any club to be drawn as long as it is not a 3 or 8 face giving us 13 – 4 – 2 = 7 other cards to pick from.

$$P(Flush) = \frac{7\ \#\ of\ hands}{48\ total\ \#\ of\ hands} = \frac{7}{48}$$

And for the straight event, we still want the 3 or 8 to be drawn but as any of the three other suits.

$$P(Straight) = \frac{2 * 3 \; \# \; of \; hands}{48 \; total \; \# \; of \; hands} = \frac{6}{48}$$

$$P(Three \; of \; a \; Kind) = 0\%$$

$$P(Two \; Pair) = 0\%$$

$$P(High \; Pair \; \{10, J, Q, K, A\}) = 0\%$$

Again, for the lower than 10 event, we take the sum of all event's probabilities and subtract it from 100% (or 1 in this case when using fractions). Giving us:

$$P(Lower \; than \; Pair \; 10) = 1 - \frac{2 + 6 + 7}{48} = \frac{33}{48}$$

Finally, the player's expected value on making a #2 Bet with the given subset can be computed as:

$$EV(Player \; Bet\#2) = -1\left(\frac{33}{48}\right) + 5\left(\frac{6}{48}\right) + 8\left(\frac{7}{48}\right) + 200\left(\frac{2}{48}\right) = 9.4375$$

In this scenario the player should ride given this high positive expected value.