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Simulation and application in slot Machine Analytics

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ABSTRACT

This research paper deals with busting 3 major myths associated with slot machines. Here, we have used the simulation to replicate a real-life casino slot machine and use it to bust the 3 myths. The simulation was made keeping into consideration several factors such as Return-To-Player Ratio, weighted symbols, and many more to make the simulation as accurate as possible. Findings from this were then used to debunk the myths. Simulation is the imitation of a technique or operation of a system over time and under test conditions. Simulations are very beneficial for analysis as they are cost effective, considers different ideas, resolves the long-term impact, space for improvement, unbiased distributions and so on. They can be used for multiple purposes such as optimizing, testing, training, gaming, and performance evaluation (Why use simulation modeling?, n.d.).

Keywords— *Simulation, Slot Machine, Operations Research, Debunking Slot Machine Myths*

1. INTRODUCTION

Gambling has been a leisure activity for mankind since ancient times, dating back to about 3000 BC. Since then, gambling has grown and has taken different forms of games and has been inculcated in many other activities in the form of betting. Casinos have been founded, generating most of their revenue by hosting gambling activities. In recent times, with the onset of the Industrial Revolution, gambling has taken another form of slot machine. In today's age of digitalization, online slot machines have now produced a lot of scope for themselves, with the online gambling market expected to grow from $64.13 billion in 2020 to $72.02 billion in 2021. This market is also expected to reach $112.09 billion by the year 2025. (Markets, 2021)

Simulation is a very useful technique in the field of gambling. It can tell us the outcomes a slot machine will generate, according to the number of turns played. Casinos use this method to determine how they want the slot machines to run, and how much profit they should generate for the Casino. The most common form of this is the Monte Carlo simulation, which conducts a high number of simulations, leading to more accurate results.

The myths which will be debunked ahead using experiments are; 1) money will even out in the long run. According to this myth people believe that if a machine is played multiple times, the wins and losses even out. 2) jackpot could be expected by playing more or piling on to other players winning streak, which means that if a turn gives out a jackpot to a certain player, the same turn if played by another player would have resulted in a jackpot too. 3) machines are set to lose out money whenever you play. These myths are busted using the outcomes generated by the simulation. The simulation was run multiple times to generate the outcomes similar to a slot machine.

2. LITERATURE REVIEW

From the late 19th Century, the slot machine origin can be tracked down, the first slot machine was developed by the New York based company, Sittman and Pitt in 1891, consisting of 5 drums with a sum of 50 playing cards. An immigrant from Bavarian named

Charles August Fey in the United States invented the first slot machine during the span of 1887-1895. This machine worked on a simple mechanism which allowed automatic payouts with 3 spinning reels machine with 5 different symbols. Symbols consists of diamonds, hearts, diamonds, spades, horseshoes and a liberty bell. The highest payout was received on 3 bell symbols and so the game was named 'Liberty Bell'. After 60 years of mechanical slot machines, a new fully electro mechanical machine in 1964 named Money Honey which started by pulling a lever and the first to have a bottomless hopper having a payout of up to 500 coins. Fortune Coin, a Las Vegas based company in 1976 developed the first video slot machine in Kearney Mesa. Slots become a hotspot at the casinos all over the world by then and converting the hardware bound machines in the 19th century to the age of software in the 20th. This is how the transition of slot machines took place from pulling a lever to a digitalization era where in even online gaming modes can be easily accessed (Kamanas P. A., 2021).

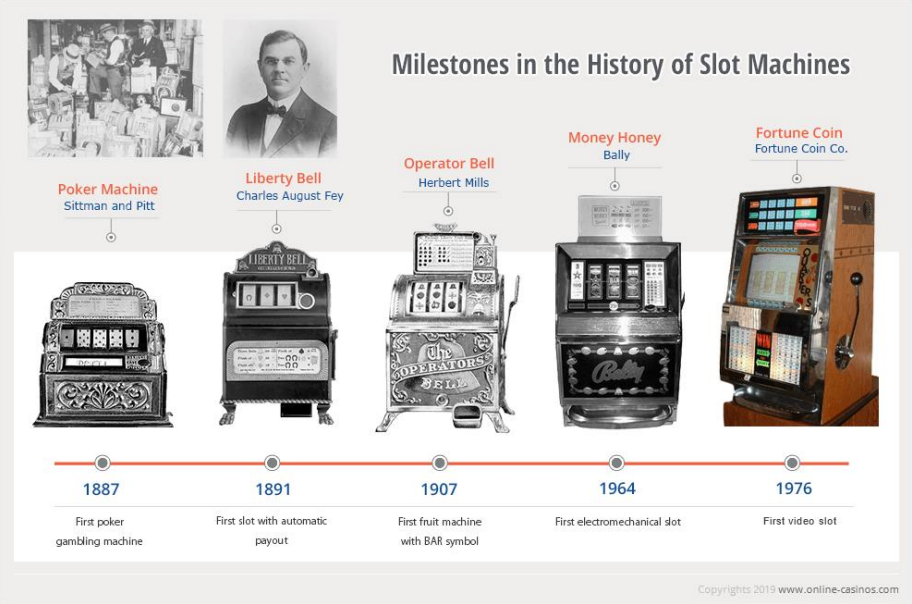


Figure - History of slot machines

The basic structure of any slot machine is that, they contain several reels, which work independently. These reels have several symbols, and a combination of these symbols determines the win or loss of a user. After dropping one or more coins into the slot machine, one gets an opportunity to press a button which causes these reels to start spinning. When the reels stop spinning, the combination of the symbols which appear are used to determine the win prize. This win prize is listed on a "payline" chart, usually displayed along the slot machine. Some symbols are more frequent than others, the more frequent the symbols, higher is the probability of them appearing, lesser is the payout (Bărboianu, 2013).

These symbols have a designated position on each reel. When a user presses the "SPIN" button, the microchip in the slot machine produces a series of random numbers. These random numbers are generated continuously ranging between 1 and billions of times every second. These random numbers are responsible for generating the positioning of the symbols in the reels. (ReviewedCasinos, n.d.). However, these random numbers are not true random numbers. In reality, the microchips use a Psuedo- Random Number Generator. This is an algorithm which uses mathematical formulae to create numbers which appear to be random, but are actually determined using different methods. These pseudo- random numbers are just as effective as true random numbers due to its speed of running the algorithm. The best method used to generate pseudo- random numbers is by using the linear congruential method (Haahr, n.d.).

The linear congruential method is defined by $X_n \equiv (aX_{n-1} + b) * mod\ m$, where, a is the integer multiplier, b is the increment, m is the modulus (divider). An initial input number known as the seed or a key is used in the formulae to generate a random number. This random number is then used as the seed for the next random number. This process is continued to generate a series of random numbers (Arobelidze, 2020). This series determines the position of the symbols on the reels, which finally decides if the user has won or not.

After the symbols are displayed, one either wins a sum of money or loses a part of it. The expected amount of money that a player gets in the long run is determined using a Return to Player Percentage (RTP) which is set by the game maker and the casino. This means, that if the RTP is 90%, for every $100 inserted into the machine, the average payout will only be $90. Therefore, $10 is lost. Then, if you re-insert the $90, the user will only get $81, and it goes on until one gives up and loses all money. This is in the long term, and is an average (Rumsey, Using Probability When Hitting the Slot Machines, 2021).

In contrast to this the 5 key statements that must be referred to rather than referring to the myths about slot machine payout rates:
1. Any slot machine is never due to hit which means that payback percentage and the win frequency can be estimated in the long run.
2. Any slot machine can either give you multiple big payouts in a shorter span or not even a decent one for a time period.
3. Playing faster cannot rise your winning chances but they seem to win more as they have played more spins.
4. The number generation is not at all based on the coins you bet.

5. Pressing a button or pulling a lever the result isn't different (Best Payout Slots, n.d.).

Each slot machine is required to have a particular range of RTP according to regulations imposed in their country. The optimization of RTP to fit into these legislations were achieved by controlling the symbols distribution. Usually, these symbols are solved by using hand adjustments, to overcome this, three algorithms have been researched so far (Todor Balabanov, 2015).

The authors of this research paper use Genetic Algorithm (GA) to optimize the RTP. Applying this algorithm helps in getting a solution which is closer to optimization. Optimization usually starts with a randomly generated group of individuals, but this is also the subject of implementation. The fitness value generally represents an objective function as an optimization object. Selection (according to selection rules) and recombination (crossing and / or mutation) to form a new generation. This new generation is used for the next iteration of the algorithm. Algorithm termination is generally achieved by reaching the maximum algebra or reaching the desired fitness value level.

In the proposed model, as a fitness function, the absolute difference between the expected RTP and the obtained RTP is used. In order to obtain Monte Carlo RTP, simulation is used to estimate the performance of the slot machine in 100,000 or 1,000,000 independent games. The rules of elitism also apply so that the best individuals can survive generations. The main disadvantage of optimization based on genetic algorithms is the time required for the calculation of the fitness value. In the slot machine reel optimization problem, the fitness value is calculated by a relatively slow simulation of the game. The biggest advantage of the optimization based on the genetic algorithm is that multiple parameters can be optimized. In this research, the RTP is optimized, but as a multi-standard optimization, you can optimize the frequency of symbols, the frequency of free spins, the frequency of the bonus game, and the volatility of the game.

Differential evolution (DE) is a population-based meta-heuristic search algorithm that optimizes problems by iteratively improving candidate solutions based on the evolutionary process. Such algorithms have either no or some assumptions concerning underlying optimization problem, and can quickly explore large design space. DE is one of the most versatile and stable population-based search algorithms, and it shows robustness to multimodal issues. The constrained optimization problem is difficult to solve due to its complexity and high degree of non-linearity (Plevris, 2020). This research paper shows that the use of DDE can be very effective and improve the performance of the slot games by better adjusting the RTP, prize balance and the diversity of symbols. However, optimizing RTP using this method is estimated to be time consuming and slows down the optimization process (Balabanov, Zankinski, & Shumanov, 2015).

This research paper shows the first time the VNS framework with the help of two local search operators to obtain the desired RTP how the distribution of symbols in reels in order should be done which refers to only the base game and not when the bonus game is triggered. By performing this the results present that the VNS is very efficient in making the slot games when there is no uniform symbol distribution. The number of iterations required depends upon the difference between the initial and target RTP. Also as complexity increases the need for speeding up the process is also necessary. The algorithm involved is a single criterion approach on RTP optimization and there can be further research on the multiple criteria method for optimizing RTP, volatility and hit rate i.e. how can a player expect to stop on placing a bet on a winning combination (Kamanas, Sifaleras, & Samaras, 2021).

3. OBJECTIVES

With this research paper, we will find a systematic and mathematical system to debunk myths such as:

- The money inserted initially will even up in the long run,
- If someone else wins a jackpot on a machine you were playing with, that jackpot could have been yours if you played it longer,
- Some machines are set to lose.

4. METHODOLOGY

The following experiments used in the research were done using a simulation of an actual casino slot machine which was coded through Python.

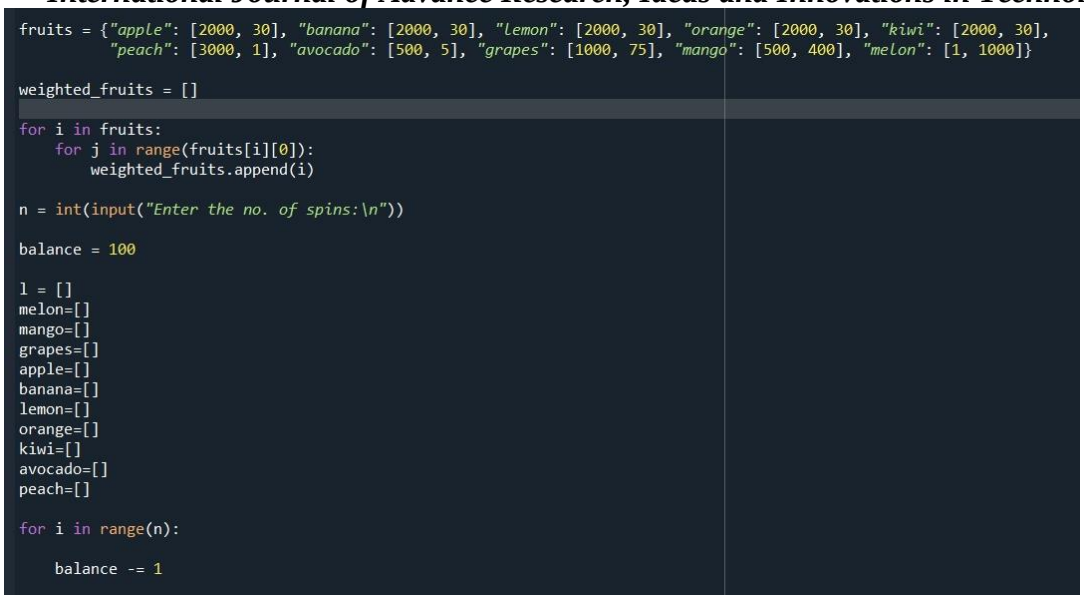
For preparing the code, the following assumptions were made:

- the slot machine user is playing a single line/row of the slot machine.
- The average payout ratio of slot machines is set to 95.6%.
- A jackpot is considered the biggest win possible in a single spin of the slot machine.
- The player bets 1$ each spin and starts with a budget of 10$.

The code contains 10 symbols as names of fruits with each assigned a monetary value.

The program starts with creating a list by adding each symbol a particular number of times according to weights calculated through RTP. Through these several number of each type of symbol, the computer picks 3 symbols through pseudo-random-number-generation, from the list, essentially working as a probability.

The 3 symbols that are chosen are then matched with the combinations on the prize table, created keeping in mind the RTP percentage. Once it is matched, the player is either allotted the prize which is added to his/her balance or is asked if he/she wants to play again on winning nothing.



```
fruits = {"apple": [2000, 30], "banana": [2000, 30], "lemon": [2000, 30], "orange": [2000, 30], "kiwi": [2000, 30],
          "peach": [3000, 1], "avocado": [500, 5], "grapes": [1000, 75], "mango": [500, 400], "melon": [1, 1000]}

weighted_fruits = []

for i in fruits:
    for j in range(fruits[i][0]):
        weighted_fruits.append(i)

n = int(input("Enter the no. of spins:\n"))

balance = 100

l = []
melon=[]
mango=[]
grapes=[]
apple=[]
banana=[]
lemon=[]
orange=[]
kiwi=[]
avocado=[]
peach=[]

for i in range(n):

    balance -= 1
```

Figure 1- Weighted Fruits – Extracted from Python

Figure 1 shows the weightage of a fruit which will be added to a list (weighted_fruits), from which a symbol is chosen to appear on the slot machine reel, followed by the winning amount. The number of times of the fruit is inversely proportional to the payout received.

Paylines	Reel 1	Reel 2	Reel 3	Payout	No. of combinations
3 Melons	Melon	Melon	Melon	1000	1
3 Mango	Mango	Mango	Mango	400	125000000
3 Grapes	Grapes	Grapes	Grapes	75	1000000000
3 of any fruits:					
Apple	Apple	Apple	Apple	30	8000000000
Banana	Banana	Banana	Banana	30	8000000000
Lemon	Lemon	Lemon	Lemon	30	8000000000
Orange	Orange	Ora	Ora	30	8000000000
Kiwi	Kiwi	Kiwi	Kiwi	30	8000000000
Avocado in any one slot	Avocado			5	105139500500
		Avocado		5	105139500500
			Avocado	5	105139500500
Peach in any 2 slots	Peach	Peach		1	108009000000
		Peach	Peach	1	
	Peach		Peach	1	

Table 1 - RTP Calculations

Winning Combinations	No. of combinations	Win amount	Payoff for $1	% Payoff
3 Melons	1	1000	1000	0.000%
3 mangos	125000000	400	50000000000	1.481%
3 Grapes	1000000000	75	75000000000	2.222%
3 of any fruits in	40000000000	30	1200000000000	35.548%
-Apple				
-banana				
-lemon				
-orange				
-kiwi				
Avo in any one slot	315418501500	5	1577092507500	46.719%
Peach in any 2 slots	324027000000	1	324027000000	9.599%
		Sum	**3226119508500**	
		Total Combinations	**3375675045001**	
		RTP	**95.570%**	=D85/D86

Table 1 shows the calculation of the payline. The number of combinations have been formulated by multiplying the weights of each fruit. In table 2, the payoff for 1 column indicated the amount a person will win if he hits the combination, when he inserts one coin of $1. The percentage payoff is calculated by dividing the "payoff for 1" column by the total number of combinations. The RTP is

then calculated by dividing the sum of "payoff for $1" to total no. of combinations. Therefore, Return to Player (RTP) percentage has come to 95.70%. Thus, figure 3 shows the payline of the slot machine made, while maintaining an RTP of 95.70%.

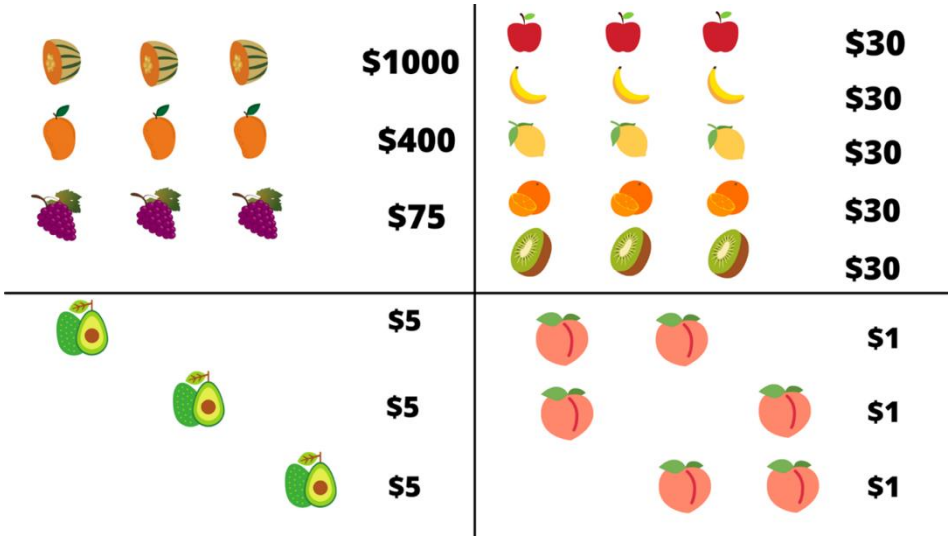


Figure 2 – Paylines

Figure 3 shows the code after the computer selects a random symbol. If the random symbol "a" is the same as the random symbol "b" and "c", and if all three are melons, the user wins $1000, and so on for each of the items mentioned in the paylines. The "print" functions display the number of times a person hits any item of the paylines.

```
balance -= 1

a = r.choice(weighted_fruits)
b = r.choice(weighted_fruits)
c = r.choice(weighted_fruits)


if(a==b==c=="melon"):
    balance+=fruits[a][1]
    l.append(i)
    melon.append(i)
if(a==b==c=="mango"):
    balance+=fruits[a][1]
    mango.append(i)
if(a==b==c=='grapes'):
    balance+=fruits[a][1]
    grapes.append(i)


if(a==b==c=="apple"):
    balance+=fruits[a][1]
    apple.append(i)
if(a==b==c=="banana"):
    balance+=fruits[a][1]
    banana.append(i)
if(a==b==c=='lemon'):
    balance+=fruits[a][1]
    lemon.append(i)
if(a==b==c=="orange"):
    balance+=fruits[a][1]
    orange.append(i)
if(a==b==c=="kiwi"):
    balance+=fruits[a][1]
    kiwi.append(i)


if(a=="avocado" and b!='avocado' and c!='avocado'):
    balance+=fruits[a][1]
    avocado.append(i)
if(a!="avocado" and b=='avocado' and c!='avocado'):
    balance+=fruits[b][1]
    avocado.append(i)
if(a!="avocado" and b!='avocado' and c=='avocado'):
    balance+=fruits[c][1]
    avocado.append(i)

if(a=="peach" and b=='peach' and c!='peach'):
    balance+=fruits[a][1]
    peach.append(i)
if(a=="peach" and b!='peach' and c=='peach'):
    balance+=fruits[a][1]
    peach.append(i)
if(a!="peach" and b=='peach' and c=='peach'):
    balance+=fruits[b][1]
    peach.append(i)
```

Figure 3 – Coding Paylines (Extracted from Python)

5. ANALYSIS AND FINDINGS

5.1 Debunking Slot Machines Myths

5.1.1 Money will even out if you play in the long run

These days, slots are primarily electronic, and they are often found either in traditional or online casinos as software. However, in virtual slots, once the reels start spinning, a Random Number Generator (RNG) is used to get the position at which they're supposed to stop. A variety of software companies within the gaming industry seek to solve the RTP optimization problem for building up modern virtual casino gambling machines.

If a slot machine player is going to play a hundred rounds at 1$ on a slot game with a theoretical slot RTP of about 95%, with all other things being equal, he/she would expect to get a return of about 95% in wins from his staked 100$.

Experiment 1: On an average, a player spins the slot machine 10 times. Keeping this in mind, we ran the code 5 times and found the average of the balances of 100 spins. After doing so, the balances of the player were as follows (Extracted from Python).
1st spin – 45
2nd spin – 96
3rd spin – 179
4th spin – 56
5th spin – 100

Therefore, even after 100 spins on an average, the user is left with $95.2. Thus, we can conclude that even if a user spins a slot machine for a long time, one will not even up the returns.

5.1.2 One could win a jackpot by just playing a little more, or piling on to another players winning streak

There is a common myth regarding the slot machines is that if a certain player stops playing at a machine, and sees that another player spins the machine, and instantly wins a jackpot/ winning sequence, the player feels that the jackpot could have been his/her if they played that turn instead of the new player.

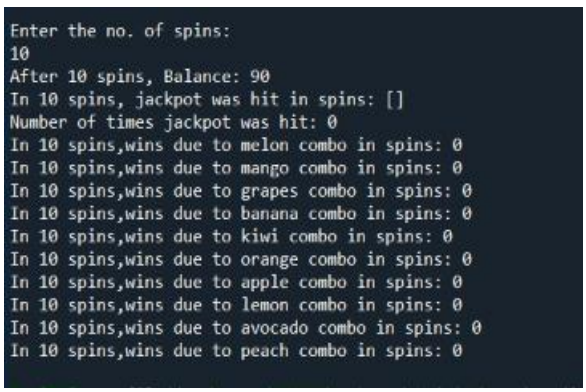
This is not true, and does not mean that the player could have won the jackpot. This is because the outcome of every spin is determined by the computers RNG (Random Number Generator). When the spin button is pressed, the RNG generates hundreds of possibilities every second in the background, and the result is locked in. To get the identical result, the player would have had to hit spin at the same instant as the new player.

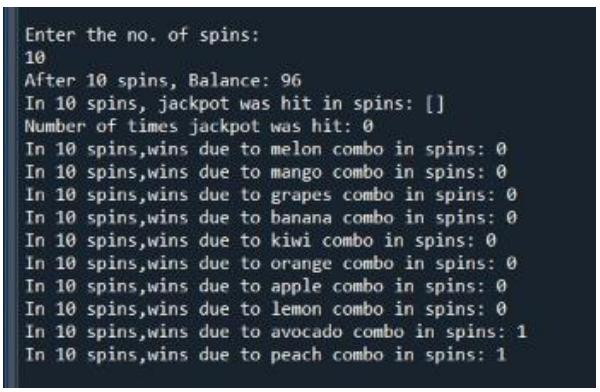
What this means for slots: Each symbol on a reel is assigned a certain value. When the reels stop spinning, a set of numbers is generated, which determines the symbols that display on your computer screen at that time. Another aspect to consider is that each symbol is weighted differently. In a game with 20 symbols per reel, this implies the chances of a symbol falling on a certain reel are practically 1 in 20 and entirely random. Moreover, the lower value symbols have been allotted a higher probability of occurring than the high-value symbols. The lower the sign, the more heavily weighted it is.

Experiment 2: In our code, we have assigned weights to each symbol (see figure 1), and the PRNG (Psuedo Random Number Generator) takes these weights into account while landing on any symbol. After running the code once for 100 times, once for 1000, and once for 10000 times, the program still didn't get a jackpot. Thus, the random numbers are such that the rare possibility is considered, and are independent of each spin.

5.1.3 Machines are set to lose

This myth basically states that the machines are set to lose out money whenever you play the game but it's not true as playing on the same machine, one can avail jackpots or even loses which clearly states that machines aren't biased towards losing out.
Experiment 3: The average spins per person is 10 times. Thus, we ran the code 4 times, each consisting of 10 spins. *Figure 5* displays the results of the same. By looking at the figure, we can conclude that the slot machines are not set to lose. It will increase your balance or decrease your balance at times. It means that the spins are based on random numbers, and thus concluding that one cannot win jackpots is false.





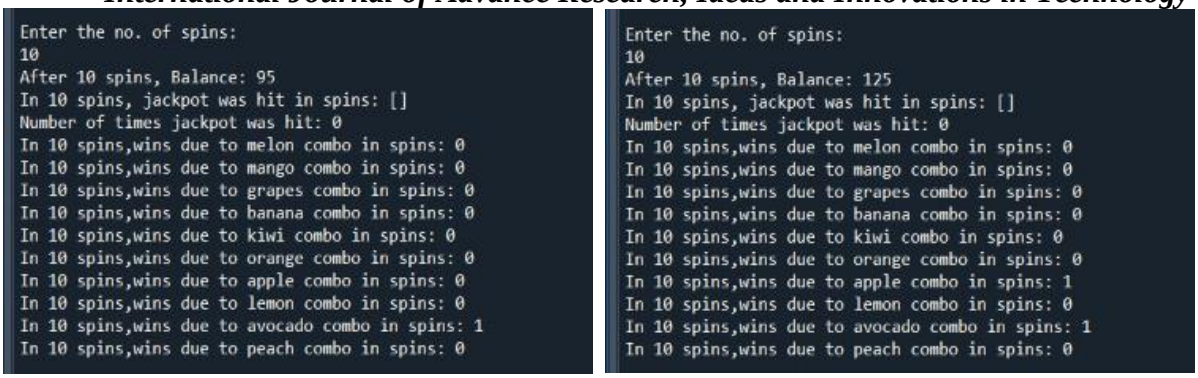


Figure 4 - Experiment 3 Outcomes

6. CONCLUSION

One of the key areas of successful game developers in making a decent slot machine is by developing a meticulously-designed artwork for it. As many people don't notice it directly but subconsciously, slot machines art design is the initial force that pulls people towards it. In the ever-busy slot gaming area of a casino, an observer might see that people only care about winning the jackpot and hitting the spin button repeatedly. This finally brings us to the main objectives of the paper as mentioned earlier above:

- *The money inserted initially will even up in the long run*

In *Experiment 1* discussed above, we saw that, how on taking an average of 5 spells of a person playing 10 times more than an average person is left with $95.20 by the end, facing a loss of $4.80. This shows that the probability of money evening up in the long run is insignificantly small.

- *If someone else wins a jackpot on the machine you were playing on, that jackpot could have been yours if you played it longer.*

In *Experiment 2* discussed above, on using the slot machine simulation for 100, 1000 and 10000 spins to learn about the occurrence patterns of jackpots, we see that, in all the rounds (i.e. 100, 1000 and 10000 spins), there was not a single jackpot that was hit (jackpot being the most amount a player can win from a single spin), which shows that jackpots in itself are extremely-extremely rare occurrences, and it occurring just after a playing session of a person being even rarer.

- *Some machines are set to lose.*

In *Experiment 3* discussed above, we took a reading of playing sessions of 5 players to see if any of them wins, out of which 1 player ended up with a higher amount after the 10^{th} spin.

What we must understand here is that these slot machines are designed with a certain Return-To-Player-Ratio. For maintaining this RTP ratio, the machine makes some players win while some lose due to number of spins not being constant. Each player has the chance to quit after each spin.

And this is the case for each and every slot machine designed. Not adhering to this can lead to license suspension of the maker and buyer of the machine. Hence it is not necessary that on some machines you are always going to lose. Through these experiments we prove wrong, 3 of the most common and deep-rooted myths of slot machine users regarding slot machines, mathematically and by experimental proof, uniquely adding to the ongoing studies on slot machines and various studies related to them, which can act as an aid to current and future research papers in their study.

The debunking of these myths will also help slot machine game designers. Through the myths, the designers can make new games and use algorithms which seek to break these myths in a more evident manner so that players can play worry-free. The working of the slot machine explained in the paper might also educate the buyers of these machines to enable them to make the proper decisions and not be duped by slot machine designers and sellers and be able to make necessary and legal tweaks in the slot machine algorithm and ratios according to the target audience.

7. LIMITATIONS AND RECOMMENDATIONS

The limitations to our research can be as follows:

1. We have assumed that the player will only bet on one reel, and that is not always the case, a player can bet on more than one reel. Player can bet on more than a single row of the slot machine.
2. There is only on jackpot in the machine i.e. on one spin that is the highest amount of prize or money a player can receive, this will reveal the amount and also remove the fun for the player to continue playing more rounds.
3. Each spin costing 1$ and given that RTP is 95.6% approx. return is always low, with jackpots being super rare, the RTP is assumed, it is different in different casinos and machines, sometime low and sometimes high as 98.7% also.

8. RECOMMENDATIONS

1. Allowing players to bet on more than one reel so that more revenue and more adrenaline rush, which might increase the player to play more rounds.
2. Random RTP in machines should be placed in the casinos, to instil curiosity amongst players.

REFERENCES

[1] 15 SLOTS MYTHS & MISCONCEPTIONS DEBUNKED! (2020, December). Retrieved from Bet and Beat: https://betandbeat.com/slots/blog/slot-myths-debunked/

[2] Angioni, G. (2021, August 17). Slot Machine Probability: a Mathematical Approach to Slots. Retrieved from casinosmash: https://www.casinosmash.com/features/how-to-use-probability-to-win-at-slots
[3] Arobelidze, A. (2020, October). Random Number Generator: How Do Computers Generate Random Numbers? Retrieved from freecodecamp: https://www.freecodecamp.org/news/random-number-generator/
[4] Balabanov, T., Zankinski, I., & Shumanov, B. (2015). Slot Machine RTP Optimization and Symbols Wins Equalization with Discrete Differential Evolution.
[5] Barboianu, C. (2013). The Mathematics of Slots: Configurations, Combinations, Probabilities. Retrieved from https://books.google.co.in/books?id=ertEkKX0YHMC&printsec=copyright&redir_esc=y#v=onepage&q&f=false
[6] Best Payout Slots. (n.d.). Retrieved from Online casinos: https://www.onlinecasinos.co.uk/blog/best-payout-slots.htm
[7] Bluejay, M. (n.d.). All about Slot Machines. Retrieved from Easy Vegas: https://easy.vegas/games/slots/
[8] Bluejay, M. (n.d.). Slot Machine Simulator. Retrieved from Easy Vegas: https://easy.vegas/games/slots/simulator
[9] Grolemund, G. (2020, February). Notes for Hands-On Programming with R. Retrieved from Keren Xu: https://xukeren.rbind.io/post/2020/02/09/notes-for-hands-on-programming-with-r/
[10] Grolemund, G. (n.d.). Hands-On Programming with R. Retrieved from rstudio-education: https://rstudio-education.github.io/hopr/loops.html
[11] Haahr, D. M. (n.d.). Retrieved from RANDOM.ORG: https://www.random.org/randomness/
[12] Harrigan, K. A. (2007, April 18). Slot Machine Structural Characteristics: Creating Near Misses Using High Award Symbol Ratios. Retrieved from link.springer: https://link.springer.com/article/10.1007%2Fs11469-007-9066-8
[13] Harrigan, K. A. (2008, July). Slot Machine Structural Characteristics: Creating Near Misses Using High Award Symbol Ratios. Retrieved from ResearchGate: https://www.researchgate.net/publication/225827479_Slot_Machine_Structural_Characteristics_Creating_Near_Misses_Using_High_Award_Symbol_Ratios
[14] How Much Time to Spend at Slot Machine. (n.d.). Retrieved from casinonewsdaily: https://www.casinonewsdaily.com/slots-guide/much-time-spend-slot-machine/
[15] Inge S. (Reno, N. (1984, May). Electronic gaming device utilizing a random number generator for selecting the reel stop positions. Retrieved from USPTO Patent full-text and image database: https://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=4,448,419.PN.&OS=PN/4,448,419&RS=PN/4,448,419
[16] Jake. (2021, June). Slot Myths Debunked. Retrieved from Las Vegas Then and Now: https://lasvegasthenandnow.com/slot-myths-debunked/
[17] Kamanas, P.-A., Sifaleras, A., & Samaras, N. (2021). Slot Machine RTP Optimization Using Variable Neighborhood Search.
[18] Khandrika, K. K. (2021, March). Slot machine project using R programming. Retrieved from Geeks for Geeks: https://www.geeksforgeeks.org/slot-machine-project-using-r-programming/
[19] Leppäsalko, T. (2017, November). SIMPLE GAMBLING OR SOPHISTICATED GAMING? Retrieved from https://core.ac.uk/reader/250151212
[20] Markets, R. a. (2021). Global Online Gambling Market Report (2021 to 2030) - COVID-19
[21] Mathematical Problems in Engineering . (2021, May 5). Retrieved from hindawi: https://www.hindawi.com/journals/mpe/2021/8784065/#B1
[22] Pishro-Nik, H. (n.d.). Independent Random Variables. Retrieved from Introduction to Probability, Statistics and Random Processes: https://www.probabilitycourse.com/chapter3/3_1_5_special_discrete_distr.php
[23] Plevris, V. (2020). A Comparative Study of Differential Evolution Variants in Constrained Structural Optimization. Retrieved from https://www.frontiersin.org/articles/10.3389/fbuil.2020.00102/full
[24] Probability: Odds of Winning at Slot Machines. (2014, January 7). Retrieved from blogspot: http://edspi31415.blogspot.com/2014/01/probability-odds-of-winning-at-slot.html
[25] ReviewedCasinos. (n.d.). The Random Number Generator in Slot Machines. Retrieved from https://www.reviewed-casinos.com/articles/slots-rng/
[26] Rumsey, D. J. (n.d.). Using Probability When Hitting the Slot Machines. Retrieved from Dummies: https://www.dummies.com/education/math/using-probability-when-hitting-the-slot-machines/
[27] Salpietra, M. (2019, August). The Science Behind Slots. Retrieved from Untamed Science: https://untamedscience.com/blog/the-science-behind-slots/
[28] Shackleford, M. (2016, August). Slot Machine Appendix 1. Retrieved from The Wizard of Odds: https://wizardofodds.com/games/slots/appendix/1/
[29] Slot machine - store results of simulations in R. (2017, May). Retrieved from stack overflow: https://stackoverflow.com/questions/43395708/slot-machine-store-results-of-simulations-in-r
[30] Slot Machine Algorithms for Pro Players. (2020, December). Retrieved from The Plaid Horse: https://www.theplaidhorse.com/2020/12/29/slot-machine-algorithms-for-pro-players/
[31] Slot Machine Math. (n.d.). Retrieved from gamblersbookcase: http://www.gamblersbookcase.com/Slots-Math.htm
[32] Slot Machine Myths. (n.d.). Retrieved from Vegas Slots: https://www.vegasslots.co.uk/myths/
[33] SLOT RNG, PRNG & RANDOMNESS. (n.d.). Retrieved from betandbeat: https://betandbeat.com/slots/randomness/
[34] Slot-Machine. (2016, November). Retrieved from GitHub: https://github.com/kphaser/Slot-Machine/blob/master/RProgramming.R
[35] SlotMachine. (2011). Retrieved from GitHub Gist: https://gist.github.com/imontantes/3828998
[36] Todor Balabanov, I. Z. (2015). Slot Machines RTP Optimization with Genetic Algorithms.
[37] Why use simulation modeling? (n.d.). From AnyModeling: https://www.anylogic.com/use-of-simulation/

