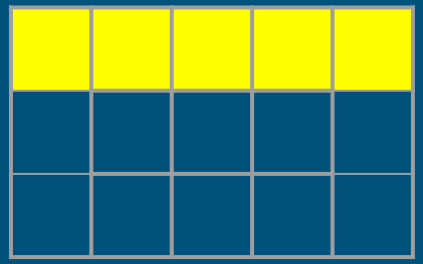
Optimizing RTP in Slot Machines While Preserving Reel Characteristics

By Ashley Del Sesto

University of Nevada, Reno

A Little Refresher

- Return to Player (RTP)
  - Average winnings returned to the player
  - 86%, 89%, 90%, etc.
  - $\text{RTP} = \frac{\text{SUM(win)}}{\text{SUM(bet)}}$
- Credits
  - Unit of currency for slot machines
  - Converted from real-life currencies & denomination amounts (1¢, $1, etc.)
- Win Patterns (or Pay Combos)
  - A pattern of symbols that yields a credit amount and/or triggers an event
  - Example: 3OAK of 10 pays 5 credits



- Screen
- Lines
  - Positions on the screen that a win pattern can appear on
  - Typically evaluated Left-to-Right
- Scatter
  - Win patterns that can appear on any position in screen

Prior Work

- Balabanov et. al., 2015: GA used to target RTP via Monte Carlo Simulations[1]
  - Each wagered game is simulated using a random seed
- Balabanov et. al., 2015: Discrete Differential Evolution (DDE) algorithm used to target 3 parameters[2]:
  - RTP
  - Pay combo hit distribution
  - Symbol diversity
- Keremedchiev et. al., 2017: GA used to target RTP via Exact RTP calculations[3]
- Kamanas et. al., 2021: Used Variable Neighborhood Search to target RTP via Monte Carlo Simulations[4]

Unexplored Territory

- Mathematical Calculation
  - Calculate probability of symbols and use math to derive RTP
  - Pros
    - Speed
    - Similar to Excel
  - “Cons”
    - Only calculates Base Game
    - Hit frequency: No coinciding line wins
- Math Models
  - **Symbol stacks**
    - **WILD stacks**
    - Other symbol stacks
    - **No stacks of a given symbol (only single-symbol appearances)**
  - Ghost/Blank symbol requirements
  - Perceived Persistence Bonus triggers
  - Base Game Feature probabilities
  - …and many more!

Aristocrat’s Gold Stacks 88 Empire Ocean Dragon Slot Machine

Old Chromosome → New Chromosome

- 2D
- Maps 1-1 with reels
- Fixed reel length for all reels

1	6	5	3	2
4	4	2	6	7
7	2	3	1	3
5	7	4	8	5
8	3	4	5	4
3	9	1	3	3
2	6	7	8	6
5	4	8	6	8
...	...	...	...	...

- 3D
- Tuple = Stack
- (symbol, count)
- Fixed # of Tuple entries for all reels
  - variable reel lengths

(1,4) =

1
1
1
1

(1,4)	(6,1)	(5,2)	(3,1)	(2,1)
(4,2)	(4,1)	(2,1)	(6,1)	(7,2)
(7,1)	(2,2)	(3,2)	(1,3)	(3,1)
(5,1)	(7,1)	(4,1)	(8,1)	(5,1)
(8,2)	(3,1)	(5,2)	(5,2)	(4,1)
(3,1)	(9,2)	(1,1)	(3,1)	(3,2)
(2,1)	(6,1)	(7,3)	(8,1)	(6,1)
(5,3)	(4,3)	(8,1)	(6,2)	(8,1)
...	...	...	...	...

Approach - GAs

- Multiple Objective Functions
  - RTP
  - Symbol Diversity
  - Bonus Hit Frequency (?)
- Fitness Function = Combination of objectives into single criteria function
- Chromosome
  - 500 tuples, 1000 elements
  - 1 <= symbol counts <=5 per tuple
- Penalties: TBD
- Pop: 50 (?)
- Generations: 100 (?)

- Tournament Selection
- Uniform X-over
  - High probability 0.9
- Mutations
  - Chance to swap two stacks
    - High probability 0.1
  - Per tuple: chance to either
    - Shift symbol (+/- 1)*
    - Shift symbol count (+/- 1)*
    - Low probability 0.001 (?)

*shifts use modulo % to prevent illegal symbols & symbol counts

Approach - Math Model

- RTP: 70%
- Bet*
  - 50 lines
  - 1 credit per line
  - no side bet
- “Easy” pays
- Left-to-Right
- Wild symbol - 1
  - Combos evaluate to symbol 2
- Bonus
- R = 5
- L = varies per reel
- Stacks = 100 per reel

Symbol Name/Count	3	4	5
11	Bonus	Bonus	Bonus

Scatter pay combos for math model

Symbol Name/Count	2	3	4	5
2	5	20	50	200
3		15	45	100
4		15	45	100
5		10	30	75
6		10	30	75
7		5	20	50
8		5	20	50
9		5	20	50
10		5	20	50

Line pay combos for math model

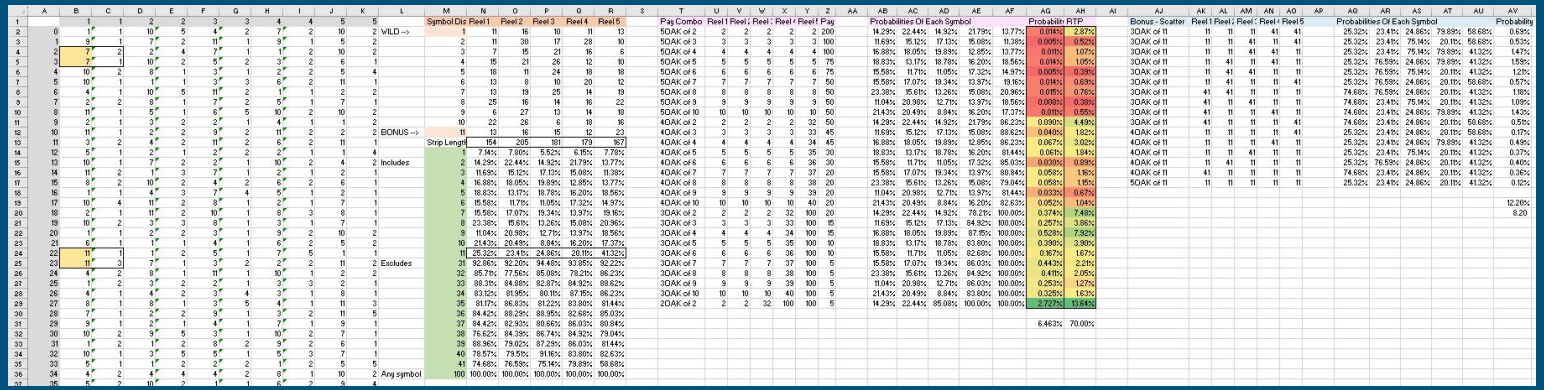
What I Have So Far

- RTP evaluation
- Chromosomal Decoding
- Tournament Selection
  - Fixing
- Uniform X-Over
- Mutations
  - Stack Swap
    - Fixing
  - Tuple Shift

paytable.csv

```
Pays
1,0,0,0,0,0
2,0,5,20,50,200
3,0,0,15,45,100
4,0,0,15,45,100
5,0,0,10,30,75
6,0,0,10,30,75
7,0,0,5,20,50
8,0,0,5,20,50
9,0,0,5,20,50
10,0,0,5,20,50
11,0,0,0,0,0
Includes
1,2,3,4,5,6,7,8,9,10
Bonus
11
Stack,1
Reels,5
Rows,3
Targets,0.7,0.5,0.008
```

User input file



Analysis of example candidate chromosome

What I Plan To Do Next

- Objective function for Symbol Diversity
- Objective function for Bonus trigger frequency
- Penalty for adjacent tuples creating stack > 5 symbols
- Penalty for stacking bonus symbol (11)
- Experiment with different probabilities for X-over & mutations

References

1. T. Balabanov, I. Zankinski, and B. Shumanov, “Slot machines rtp optimization with genetic algorithms,” in *Numerical Methods and Applications: 8th International Conference, NMA 2014, Borovets, Bulgaria, August 20-24, 2014, Revised Selected Papers 8,* Springer, 2015, pp. 55–61.
2. T. Balabanov, I. Zankinski, and B. Shumanov, “Slot machine rtp optimization and symbols wins equalization with discrete differential evolution,” in *Large-Scale Scientific Computing: 10th International Conference, LSSC 2015, Sozopol, Bulgaria, June 8-12, 2015. Revised Selected Papers 10,* Springer, 2015, pp. 210–217.
3. D. Keremedchiev, P. Tomov, and M. Barova, “Slot machine base game evolutionary rtp optimization,” in *Numerical Analysis and Its Applications: 6th International Conference, NAA 2016, Lozenetz, Bulgaria, June 15-22, 2016, Revised Selected Papers 6,* Springer, 2017, pp. 406–413.
4. P.-A. Kamanas, A. Sifaleras, and N. Samaras, “Slot machine rtp optimization using variable neighborhood search,” *Mathematical Problems in Engineering*, vol. 2021, pp. 1–8, 2021.