Using Game Theory To Study Optimizations in Buckshot Roulette Strategy

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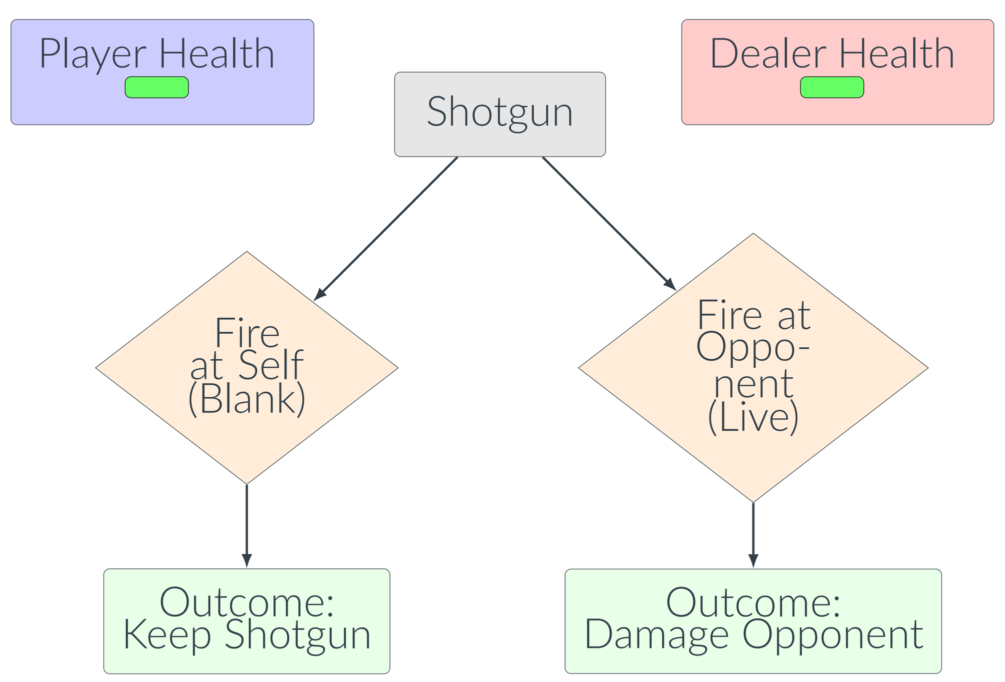
Introduction

Buckshot Roulette, a popular indie game created on December 29th 2023, is a strategic twist on Russian Roulette where the player and dealer take turns firing a shotgun loaded with live and blank shells. Live shells damage the opponent, while blank shells let the player keep the gun and act again. The goal is to reduce your opponent's health to zero. Our project uses game theory to simulate and analyze this system, focusing on simplified conditions to find optimal strategies.

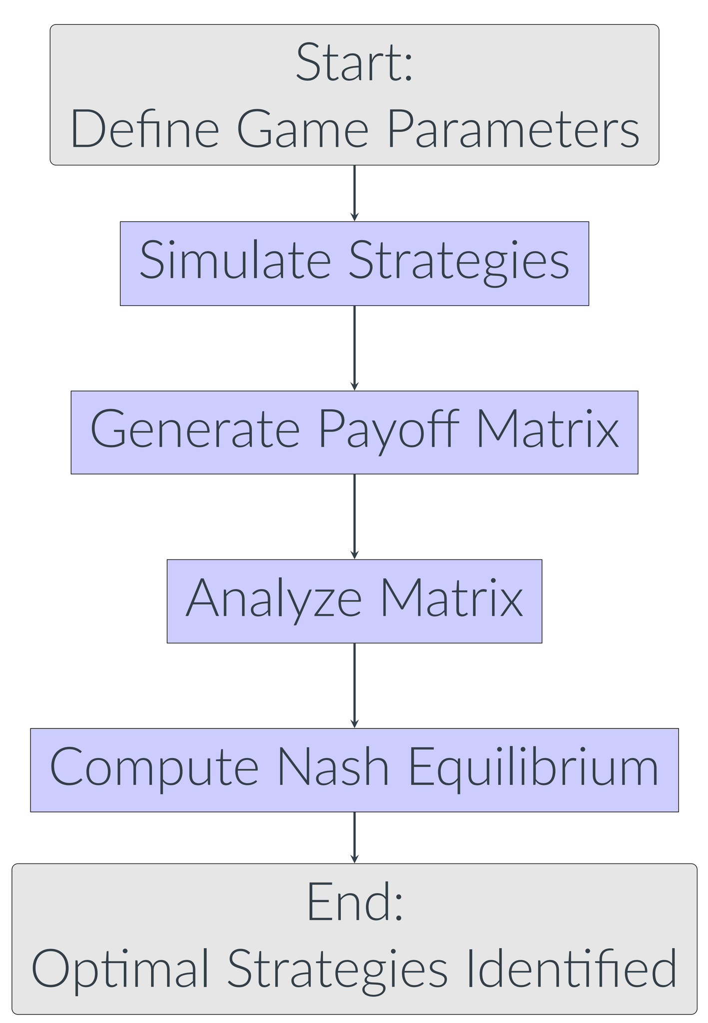


Game Theory Concepts

- Strategic Decision Making
- Risk vs Reward
- Optimal Strategy Analysis

Theory: Game Theory

Game theory allows us to model interactions between players with different strategies. Buckshot Roulette is a **non-cooperative**, **zero-sum**, **sequential** game with imperfect information [1]. Player and dealer choices directly affect each other's outcomes, and there may be multiple Nash equilibria.



To analyze the game, we:

1. Define the rules, player options, and game states.
2. Simulate different strategy combinations.
3. Generate a payoff matrix from the simulation results.
4. Apply mathematical analysis to identify optimal responses.

A Nash equilibrium occurs when no player can unilaterally improve their outcome by changing their strategy [2].

Result 1: Game Without Items

To better understand how outcomes emerge from different shell configurations, we first calculated the total number of ways live and blank shells can be arranged for each (l, b) case (Table 1).

live/blanks	1	2	3	4
1	2	3	4	5
2	3	6	10	15
3	4	10	20	35
4	5	15	35	70

Table 1: Combination Counts

We then computed how many of those arrangements result in a player win (Table 2).

live/blanks	1	2	3	4
1	2	2	2	3
2	2	4	6	9
3	3	7	13	22
4	4	11	24	46

Table 2: Win counts using $W(l, b)$

These totals help explain the probabilities observed in the payoff matrix for the l_2b_2 case.

Payoff Matrix for l_2b_2 Case:

Player/ Dealer	DDD	DDP	DPD	PDD	PPD	DPP	PPP
pp	0.666	0.5	0.666	0.166	0.333	0.5	0.0
pd	0.666	0.5	0.666	0.333	0.5	0.5	0.0
dp	0.666	0.5	0.166	0.5	0.5	0.5	0.0
dd	1.0	1.0	1.0	0.5	0.5	1.0	0.0

The payoff matrix displays outcomes for all player-dealer actions. **D** = player shoots dealer, **P** = player shoots self, **d** = dealer shoots dealer, **p** = dealer shoots player. The Nash equilibrium shows the optimal strategy is for the player to always shoot the dealer.

Method: Relaxation

In the original game, there can theoretically be an infinite series of turns. It would be impossible to code every possible game, so we decided to cut off each simulation after each player makes their turn, and then assign a k-value to whoever possesses the turn next if no one has been shot. This k-value is a stand-in for how effective it is to have the turn (considering the items each has) and was found after fine-tuning it based on the code output.

Result 2: Item Involved

We used a custom simulator and matrix generator built in Google Co-Laboratory to compute Nash equilibrium. For each l_nb_n case, we enumerated all six player and dealer actions. Each action pair produced a player payoff, forming the matrix. We repeated this across four item states: no items, Handcuffs, Magnifying Glass, or both.

Payoff Matrix for l_4b_4 Case:

Player/ Dealer	SP	SD	C → SP	C → SD	G	G → C
SP	0.094	0.75	0.094	0.594	0.619	0.619
SD	0.5	0.906	0.475	0.725	0.75	0.725
C → SP	0.044	0.725	0.044	0.544	0.569	0.569
C → SD	0.294	**0.725**	0.294	0.544	0.569	0.569
G	0.069	0.75	0.069	0.569	0.594	0.594
G → C	0.019	0.725	0.019	0.519	0.544	0.544

Nash Equilibrium :

Expected Value (Player): 0.725

Player = 'Shoot Dealer'

Dealer = 'Use Cuffs, then Shoot Player'

For each l_nb_n case, we generated 16 payoff matrices, one for each item combination. These were averaged into a single matrix per case. The resulting matrix, like the l_4b_4 example in Table 1, was fed into a Nash Equilibrium solver. The output identified the optimal strategies: Player = "Use Cuffs, then Shoot Dealer" and Dealer = "Use Cuffs, then Shoot Player." Color gradients highlight payoff strength across action pairs.

Conclusion

The results show that the payoff matrices align with standard probability. Actions involving shooting yourself are disfavored when live shells outnumber blanks, due to a higher risk of self-elimination. The Handcuffs item tends to favor targeting the dealer, as using it on yourself often results in a loss or wasted effect [3]. These trends are also noted in player and critic reviews [4].

References

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