Best Possible Payoff Strategy for a Perfect Truel Game

Introduction

The phrase "survival of the fittest" originated from Darwinian evolutionary theory as a way of describing the mechanism of natural selection. This mechanism states that the fittest in the struggle for survival and reproduction increase in number, which ultimately leads to the design that we see in nature. The phrase "survival of the fittest" was coined in the early 1900s. However, there are circumstances in which survival of the fittest does not always occur; the extinction of the dinosaurs is a prime illustration of this phenomenon.

In the research that has been done on truels, a broad number of different situations and settings, such as rigging the game so that the player with the lowest skill level gets to shoot first and the player with the highest skill level gets to shoot last, have been investigated. A simultaneous truel is an additional possibility that can be thought of as a generalization of the traditional duel. In this variation, all three participants fire their bullets at the same moment. Additionally, winning methods are researched for a random truel, which is a type of tournament in which each player is selected at random from the players who have survived each round.

In earlier research, the principle was also utilized in a voting model, which produced a seemingly contradictory outcome. It was determined that a subsequent increase in support for a candidate following an earlier drop in support for the candidate leads in a surge in the polls for the politician. In addition, there have been studies that have used the rock-scissors-paper model to ecosystems that have three different species that interact with one another and, ultimately, produce a competitive loop. The paradoxical impact of this model is that the species with the lowest level of competition has the ability to amass the greatest number of individuals inside the ecosystem. In addition, Parrondo's games depict a paradoxical situation in which losing gambling games, when performed in a random or periodic order, might result in a winning outcome. This condition can occur when the games are played in succession.

The rules of the game will have a significant impact on the final result of the game. In many situations, truels can have results that are counterintuitive, and the player who has the highest marksmanship may not necessarily have the best chance of surviving. The unexpected result of "survival of the weakest" can sometimes be reached by the use of probability-based calculations.

What is a Truel?

A truel is an enlargement of a duel that involves three participants. During a truel, each participant has the opportunity to try to stay alive by firing at their opponents in an effort to eliminate them.

Truel and triel are both neologisms that refer to a type of duel that takes place between three adversaries and allows players to fire at one another in an effort to eliminate the other players while still preserving their own lives.

In game theory, a wide number of different types of truels have been investigated. The nature of a truel can be determined by a number of factors, such as the probability of each player hitting their chosen targets (which is not always assumed to be the same for each player), whether the players shoot simultaneously or sequentially, and, if sequentially, whether the shooting order is predetermined, or determined at random from among the survivors; the number of bullets each player has (in particular, whether this is finite or infinite); and whether or not intentionally missing is allowed. Other factors include whether or not intentionally missing is whether or not self-targeting or selecting targets at random is permitted.

It is generally accepted as a given that all of the players in the truel are motivated by the desire to emerge victorious and will act in a manner that is rationally consistent with the goal of achieving this status as soon as possible.(If each player merely wants to survive and does not care if the others also survive, then the most sensible approach for all three players could be to miss every time.)

Perfect Truel Game Strategies

1. Targeting the Strongest Opponent:-

The winner in a sequential truel is the last player standing after all three players have fired their shots. Player A with marksmanship a, player B with marksmanship b, and Player C with marksmanship c each take turns firing bullets at targets of their choice where $0 \leq a \leq b \leq c \leq 1$.

The tactic of firing at the opponent as a target with the best marksmanship appears as a smart choice. When all three players are present, player A fires at C, player B fires at C, and player C fires at B.

But this strategy can only give good odds according to the order of shooting. If the order of shooting is not appropriate then the odds of winning can be pretty low for the players.

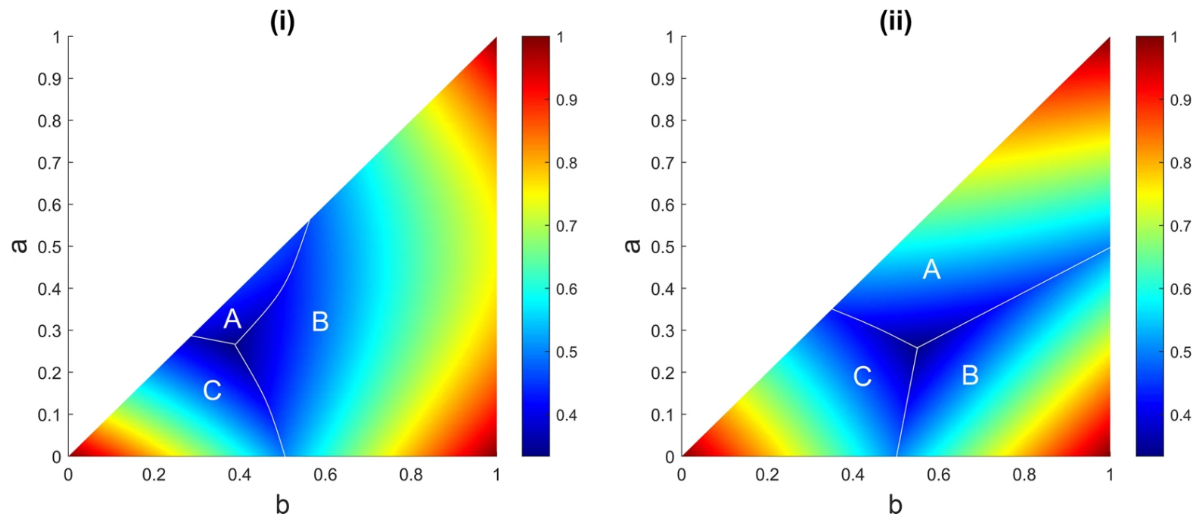
2. Targeting an opponent versus abstention: -

Although the naive thought process is that shooting the strongest opponent approach is the best strategy for player A, we can see that by shooting into the air in the first round or whenever both other players are alive, player A can boost his chances of survival

The reason for this is that the shooters with higher accuracy B and C are aware that they pose a greater threat to each other than A does to them. This suggests they'd rather shoot at each other until one of them died. As a result, A will always survive until only two people remain and he will always be the first to shoot. This occurs regardless of the shooting sequence.

One notable example is when A is the first shooter. In that situation, he does not want to risk killing B or C since he would then have to deal with the second shot in a head-to-head match. His best tactic is to purposefully miss/fire in the air, allowing B and C to fire at each other. As a result, A will be the opening shot in the two-person duel.

In particular, the sequential truel can transform into a sequential duel at any time. Being the first shooter in a sequential duel can be more advantageous than marksmanship in some instances because the opponent's marksmanship does not come into play until he takes his turn.



Case i - It depicts the case where player A aims at the player with maximum accuracy

Case ii - It depicts the case when play A adopts a strategy of abstention by shooting in the air during a sequential truel.

In the plots, we have set c=1. The result is remarkable as player A's chances for survival are dramatically increased by choosing the strategy of abstention rather than firing at the strongest opponent.

.

EXPLANATION

I. Setting up game environment

Consider an arbitrary situation where we create a truel game taking these into account :

Here P() is the probability of player shooting the bullet

Assumption : Considering Probability of A to always shoot accurately and never miss

Hitting Percentage

A : 100 %

B : 80 %

C : 50%

P(A hits) = 1

P(A misses) = 0

P(B hits) = 0.8

P(B misses) = 0.2

P(C hits) = 0.5

P(C misses) = 0.5

The probability that S survives when the current shooting order is ABC will be denoted by the notation P(S,ABC).

II. Survival Rate calculation when two person are left

Shooting order:	Survival chance A:	Survival chance B:	Survival chance C:	Explanation:
AB	P(A,AB) = 1	P(B,AB) = 0	P(C,AB) = 0	A never misses.
AC	P(A,AC) = 1	P(B,AC) = 0	P(C,AC) = 0	A never misses.
BA	P(A,BA) = 1/5	P(B,BA) = 4/5	P(C,BA) = 0	P(A,BA) = P(B misses) × P(A,AB) = 1/5. P(B,BA) = P(B hits) + P(B misses) × P(B,AB) = 4/5.
BC	P(A,BC) = 0	P(B,BC) = 8/9	P(C,BC) = 1/9	P(B,BC) = P(B hits) + P(B misses) × P(C misses) × P(B,BC) = 4/5 + 1/5 × 1/2 × P(B,BC), which gives P(B,BC) = 8/9. P(C,BC) = P(B misses) × P(C hits) + P(B misses) × P(C misses) × P(C,BC) = 1/5 × 1/2 + 1/5 × 1/2 × P(C,BC), which gives P(C,BC) = 1/9.
CA	P(A,CA) = 1/2	P(B,CA) = 0	P(C,CA) = 1/2	P(A,CA) = P(C misses) = 1/2. P(C,CA) = P(C hits) = 1/2.
CB	P(A,CB) = 0	P(B,CB) = 4/9	P(C,CB) = 5/9	P(B,CB) = P(C misses) × P(B hits) + P(C misses) × P(B misses) × P(B,CB) = 1/2 × 4/5 + 1/2 × 1/5 × P(B,CB), which gives P(B,CB) = 4/9. P(C,CB) = P(C hits) + P(C misses) × P(B misses) × P(C,CB) = 1/2 + 1/2 × 1/5 × P(C,CB), which gives P(C,CB) = 5/9.

III. Calculation of likelihood that three people will survive. This is accomplished by examining the first shooter's odds of surviving for each of the four possible techniques.

Shooting order:	Survival chance when shooting at A:	Survival chance when shooting at B:	Survival chance when shooting at C:	Survival chance when missing deliberately:	Conclusion:
ABC	0	P(A hits) × P(A,CA) + P(A misses) × P(A,BCA) = 1/2	P(A hits) × P(A,BA) + P(A misses) × P(A,BCA) = 1/5	P(A,BCA) < 1/2 (since B will definitely shoot at A, because P(B,AB) = 0!)	So, A shoots B, which means that P(A,ABC) = 1/2, P(B,ABC) = 0, and P(C,ABC) = P(C,CA) = 1/2
ACB	0	P(A hits) × P(A,CA) + P(A misses) × P(A,BCA) = 1/2	P(A hits) × P(A,BA) + P(A misses) × P(A,BCA) = 1/5	P(A,CBA) < 1/2 (since B will definitely shoot at A, because P(B,ABC) = 0!)	So, A shoots B, which means that P(A,ACB) = 1/2, P(B,ACB) = 0, and P(C,ACB) = P(C,CA) = 1/2
BAC	P(B hits) × P(B,CB) + P(B misses) × P(B,ACB) = 16/45	0	P(B hits) × P(B,AB) + P(B misses) × P(B,ACB) = 0	P(B,ACB) = 0	Therefore, B shoots A, which means that P(B,BAC) = 16/45, P(A,BAC) = P(B misses) × P(A,ACB) = 1/10, and P(C,BAC) = P(B hits) × P(C,CB) + P(B misses) × P(C,ACB) = 49/90

CAB	P(C hits) × P(C,BC) + P(C misses) × P(C,ABC) = 11/36	P(C hits) × P(C,AC) + P(C misses) × P(C,ABC) = 1/4	0	P(C,ABC) = 1/2	So, C should miss deliberately (fire "into the air"), which means that P(C,CAB) = 1/2, P(A,CAB) = P(A,ABC) = 1/2, and P(B,CAB) = P(B,ABC) = 0
BCA	P(B hits) × P(B,CB) + P(B misses) × P(B,CAB) = 16/45	0	P(B hits) × P(B,AB) + P(B misses) × P(B,CAB) = 0	P(B,CAB) = 0	Therefore, B shoots A, which means that P(B,BCA) = 16/45, P(A,BCA) = P(B misses) × P(A,CAB) = 1/10, and P(C,BCA) = P(B hits) × P(C,CB) + P(B misses) × P(C,CAB) = 49/90
CBA	P(C hits) × P(C,BC) + P(C misses) × P(C,BAC) = 59/180	P(C hits) × P(C,AC) + P(C misses) × P(C,BAC) = 49/180	0	P(C,BAC) = 49/90	So, C should miss deliberately (fire "into the air"), which means that P(C,CBA) = 49/90, P(A,CBA) = P(A,BAC) = 1/10, and P(B,CBA) = P(B,BAC) = 16/45

IV. Final Survival chances for A, B, C:

Shooting order:	Survival chance of A:	Survival chance of B:	Survival chance of C:
ABC	P(A,ABC) = 1/2	P(B,ABC) = 0	P(C,ABC) = 1/2
ACB	P(A,ACB) = 1/2	P(B,ACB) = 0	P(C,ACB) = 1/2
BAC	P(A,BAC) = 1/10	P(B,BAC) = 16/45	P(C,BAC) = 49/90
CAB	P(A,CAB) = 1/2	P(B,CAB) = 0	P(C,CAB) = 1/2
BCA	P(A,BCA) = 1/10	P(B,BCA) = 16/45	P(C,BCA) = 49/90
CBA	P(A,CBA) = 1/10	P(B,CBA) = 16/45	P(C,CBA) = 49/90
Total survival chances (sum of the probabilities divided by 6):	27/90	16/90	47/90

V. Output of this game :

C won by probability 47/90 or 0.522

Conclusion

It is well known that the strongest participant in a duel does not always come out on top when the stakes are raised to their maximum. When taking into account the many tactics utilized in a sequential truel, it may come as a surprise to learn that the player who possesses the highest level of marksmanship does not always have the best chance of surviving.

The regulations of the truel have a significant impact on the outcome of the game, which is entirely determined by those rules. In many situations, truels can have results that are counterintuitive, and the player who has the highest marksmanship may not necessarily have the best chance of surviving. The unexpected result of "survival of the weakest" can sometimes be reached by the use of probability-based calculations. We intend to do an analysis of the game as well as the many tactics that can be utilized in order to give a reward strategy profile that is optimal for a variety of participants.