Combinatorial and Probability Analysis of Balatro's First Hand: Winning Probabilities and Average Score

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***Abstract*—*Balatro*, a rougelike deckbuilding game, has received a lot of attention of many audiences globally. It is a charming indie game that can even compare to some triple-A games, as it was nominated for the Game of the Year award at The Game Awards 2024. Developed by an anonymous developer called LocalThunk, *Balatro* has been released since 20 February 2024 and has sold millions of copies across the world. This is due to its unique gameplay, combining the usual genre of indie games with the classic game of *Poker*, with each run ensuring different experience for the player. Aside from how fun it is to play it, the game is also interesting to analyze using mathematical concepts, since it's essentially a game of chance, such as combinatorics and graph theory. With the game analyzed, players can understand more about the mathematical properties of *Balatro* and could also leads to the invention of strategies to play the game optimally.**

Keywords*—*Poker; Combinatorics; Probability; Video Games; Roguelike.

I. INTRODUCTION

The hit game called Balatro has caused a substantial number of changes on the perspective of the gaming industry, especially in indie games. Using rather simplistic art style and mechanics, it got nominated for the Game of The Year award at The Game Awards 2024 (alongside other triple-A games that have more complex features compared to Balatro). The game has inspired many other indie game developers to thrive and blossom in the gaming industry; some even took direct inspiration from it.

Balatro is a game where roguelike and deckbuilding mechanics are implemented into a classic Poker game. Instead of facing another player, the player will face a blind that needs a certain amount of score from playing one to five cards that are present in the player's "hand". Certain combinations of cards played that are akin to the original Poker game (such as pairs, two pairs, full house, etc.) can result in more scores obtained. Seems simple at first, but with the addition of other mechanics such as joker cards, card enhancements, tarot cards, etc. makes every run unique and interesting.

Aside from the gameplay itself, Balatro also has its intrigue analysis from a mathematical perspective, since it's essentially a game of chances. The game revolves heavily around probabilities, engaging the player to think strategically about the risk and reward of a certain action while playing. The game itself can be analyzed using various mathematical concepts, such as combinatorics and graph theory.

II. THEORETICAL BASIS

A. Balatro

Developed by LocalThunk, Balatro is a round-based roguelike deckbuilding card game where the player builds poker hands to score points [1]. The term roguelike is a game genre that means the game is like the game Rogue that was released in 1980, with characteristics that consist of randomly generated content, permanent consequences, and turn based [2]. On the other hand, deckbuilding games has the main focus of building a deck by playing the game [3].

It's a charming indie game that looks simple at first but holds interesting and unique interactions between elements of the game to create complex mechanics within. It was released on 20th February 2024 as a game that can be played on PC and console [4], [5]. As for now, Balatro is available on PlayStation, Xbox, Nintendo Switch, PC, macOS, and mobile devices [1]. Balatro's rougelike elements within ensures that every playthrough or run never identical, making the game endlessly replayable [1].

To start a Balatro run, the player needs to choose a deck to play with. Each deck has different effects that can alter the run dramatically, such as giving one additional discard each round, making the hand size bigger, etc. In total, there are 15 decks that the player can choose from. In this paper, the effect of each deck will be ignored for the sake of simplicity (some effects will affect later calculations that require a far more complex analysis). Some decks are locked initially and can be unlocked after winning with a certain deck. There are also certain difficulties called "stakes" that can be applied to the run.

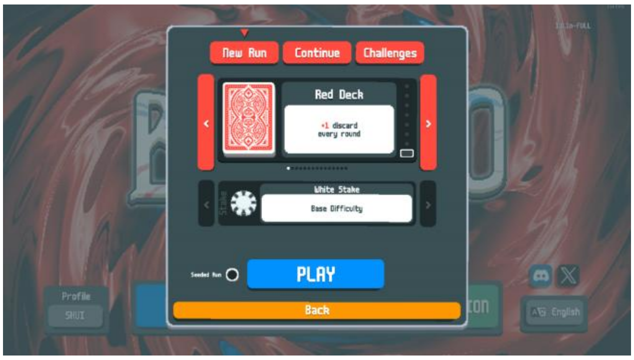

Fig. 1. Selecting a deck.

The run starting off at the first level or "ante" and faces the player with "blinds": small, big, and boss blinds. There are two categories of boss blind: regular and finale (appears at ante multiples of 8) [6]. The player can choose whether to play the blind or to skip it to grant additional effect called "tag", except for boss blinds that can't be skipped. Each of those blinds requires the player to reach a certain score by playing poker hands, with boss blind giving certain gameplay effects to make defeating it difficult. Defeating the boss blind will advance the player to the next ante with more score required for each blind.

The main gameplay of Balatro is when the player faces the blind, where the player needs to get score from playing poker hands to reach a certain threshold. Each of blind encounters are called "round". Initially, the player will have a standard 52-card poker deck that consists of cards rank 2 to ace for each 4 suits (diamonds, clubs, hearts, spades), four hands (how many times the player can play cards in hand to score), three discards (how many times the player can discard cards in hand to find better cards in deck), no starting jokers (located at the top middle box in Fig. 2), and no items in inventory (located at the top right box in Fig. 2). At the start of a round, the game will draw 8 cards as a starting hand (located at the middle bottom in Fig. 2).

Fig. 2. An example of the start of round 1 using red deck.

The player can choose whether to play up to five cards in hand to score or discard up to five cards in hand to find better cards in the deck to make better poker hands. Certain combinations of played cards can grant higher scores than others based on the hand type, called poker hand in-game, that those cards created. Since Balatro is based on a real-life game Poker, poker hands in Balatro are also based on that, such as high card, pair, flush, straight, full house, etc. Each poker hand will grant different base chips and mults that will be used for scoring. The information of each poker hand can be seen in the game, making the game accessible for players that have never played a game of Poker before. There are nine different poker hands that can be created in a played hand, which are

- **straight flush** (base chips: 100; base mults: 8): consist of straight and flush,
- **four of a kind** (base chips: 60; base mults: 7): consist of four cards with the same rank,
- **full house** (base chips: 40; base mults: 4): consist of two cards with the same rank and three cards with the same rank that differs from the two,
- **flush** (base chips: 35; base mults: 4): consist of five cards with the same suit except if it contains a straight,
- **straight** (base chips: 30; base mults: 4): consist of five cards with rank can be ordered with increment of one ({ace, two, three, four, five} also counts) except if it contains a flush,
- **three of a kind** (base chips: 30; base mults: 3): consist of three cards with the same rank except if it contains a full house,
- **two pair** (base chips: 20; base mults: 2): consist of two pairs of cards with the same rank except if it contains a full house,
- **pair** (base chips: 10; base mults: 2): consist of a pair of cards with the same rank except if it contains a two pair, a three of a kind, or a full house, and
- **high card** (base chips: 5; base mults: 1): when played card doesn't make any other poker hand.

Additionally, every played card that contributes to creating a hand type will be scored as chips based on the rank of the cards, with number cards (2–10) grant chips according to the number, face cards grant 10 chips, and ace cards grant 11 chips. The score is calculated by adding base chips and additional chips from cards then multiplying it with base mult. Some jokers can also increase chips and/or mult for each played hand for better scoring. But since the paper revolves around only the first round of Balatro, jokers and items with their mechanics won't be covered because the player won't encounter those in the first round.

When the scores reach the required threshold, the round ends and the game provides money (in dollars) to the player based on blind defeated, hands remaining, and interests. Defeating a small, big, regular boss, and finale boss blind will grant the player 3, 4, 5, and 8 dollars of money each. The game will also grant the player money corresponding to how many hands remain at the end of the round (so it's generally better to use the least amount of hand to score). Additionally, interests can also grant money based on how much money the player already has before, with every 5 dollars money corresponding to a dollar of additional money from interest (maximum of 5 dollars interest).

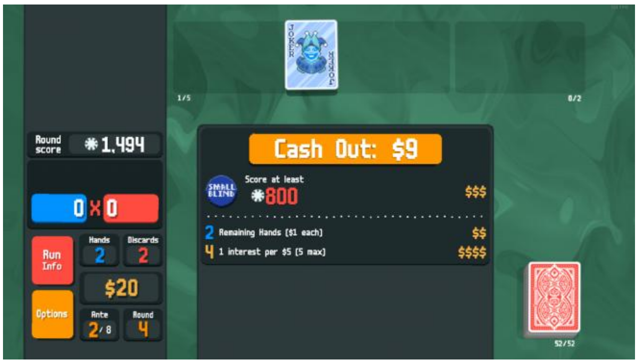

Fig. 3. The game rewarding money after a round ends.

After a round ends, the game will direct the player to the shop. The shop is a place where the player can buy jokers, items, packs, and/or vouchers to assist the player on beating the game, whether to enhance scoring, alter the deck (adding new cards, destroy cards in deck, or enhance cards in deck to have additional effects), and other means. Shops are essential to encounter in a run because they can provide means to scale chips and mults obtained from playing hands so the player can face and defeat later blinds that also scale the required score with ante. Since there are interests, it's generally better to hold onto the money (25 dollars for maximum interests) to get more money from interest in later rounds.

Fig. 4. Example of a shop after a round.

To win Balatro in a run, the player must defeat the finale boss blind in ante 8. After that, the player can choose to end the run or continue to endless mode. In endless mode, the ante can theoretically scales indefinitely. But since the program can't handle big numbers, the player can only reach ante 39 with the required scores for each blind overflowed to *naneinf* that renders the player not able to beat any of the blind.

Even only in the first round, there are lots of possibilities of gameplay that can be done by the player to progress the game forward. Different strategies can lead to different outcomes, such as beating the blind, amount of hands to beat the blind, how much money accumulated at the end of the round, and others. Those possibilities can be analyzed using mathematical concepts such as combinatorics and graph theory to understand more about the game.

B. *Combinatorics*

Combinatorics is one of the branches of mathematics to count how many arrangements of objects can be made without enumerating all the possible arrangements [7]. This particular field is very useful in everyday use. For example, combinatorics can be used to count how many passwords combination a safe has to determine the average time of a person cracking the password, how many paths to take from one place to another, etc.

In combinatorics, there are two basic rules of counting that make the base in combinatorics: sum rule and product rule. According to [8], sum rule state that if an experiment can end up either on N_1, N_2, …, or N_m outcomes and there is no overlap between those outcomes, then the number of possible outcomes of said experiment is as follows.

$$\text{Number of possible outcomes} = N_1 + N_2 + \ldots + N_m \quad (1)$$

Also, according to [8], product rule state that if an experiment has m stages, each stage has N_i with i being the stage number, the total number of outcomes of said experiment is as follows.

$$\text{Number of possible outcomes} = N_1 \times N_2 \times \ldots \times N_m \quad (2)$$

Another useful concept from combinatorics are permutations. The number of how many N distinct objects can be ordered is called a permutation [8]. For example, the permutation of three letters "a", "b", and "c" is 6, because there are 6 unique arrangement which are "abc", "acb", "bac", "bca", "cab", and "cba". The formula for permutation for N distinct objects is as follows.

$$\text{Permutation} = N! = N \cdot (N-1) \cdot \ldots \cdot 2 \cdot 1 \quad (3)$$

with $N!$ is read as "N factorial" (note that $0! = 1$ because there is only one way to arrange 0 objects).

An example for the application of permutation is in a poker deck. A standard poker deck consists of 52 unique cards. Since there are 52 distinct objects in the deck, there are 52! ways to arrange those cards in a deck (approximately 8.06 × 10^67 ways).

The concept of permutation also has a different form named k-Permutation (notation: $P(n, k)$). The definition as follows: k-permutation is an arrangement of a set with k members of n members where order matters [8]. In other words, there are $P(n, k)$ ways to arrange only k out of n different objects. Note that the order matters in this case. The following is the formula of $P(n, k)$.

$$P(n,k) = \frac{n!}{(n-k)!} \quad (4)$$

Finally, a useful concept from combinatorics is combinations, which is a special form of permutations [7]. Combinations are sometimes also known as k-combinations that's defined as: a selection of *k* objects from *n* different objects [8]. Note that the order doesn't matter in this case. The notation of *k*-combinations is $C(n, k)$, where

$$C(n,k) = \frac{P(n,k)}{k!} = \frac{n!}{k!(n-k)!} \quad (5)$$

An example use of combinations in everyday life is to count how many different ways to draw 8 cards from a standard poker deck, where order doesn't matter. Since there are 52 distinct cards in a deck, and drawing cards is the same as selecting cards from the deck, there are $C(52, 8)$ ways to do said thing (or exactly 752.538.150 ways).

C. *Probability*

Another branch of mathematics that is useful for this paper is probability. Probability is a study to calculate the likelihood of a certain event happening. In terms of *relative frequency*, probability can be interpreted as follows: to say there's a 50% chance of an event occurring, if repeated many times, approximately the said event occurs half the time [9]. There are several definitions that need to be covered to understand probability.

First, sample space. In a certain experiment, sample space is a set of all possible outcomes in said experiment (denoted as *S*) [8]. For example, a single coin flip can lead to the coin landed on either head or tail, so the sample space is $S = \{H, T\}$. Another example can be found when picking eight cards from a standard poker deck. Since there are 52 cards in a deck, the number of members in the sample space of it, or sample size, is $|S| = C(52,8)$, or can be interpreted as if there are $|S| = C(52,8)$ different ways to pick 8 cards from a 52 cards deck. The calculation of sample size relies heavily on combinatorics concepts.

Second, an event. It's defined as any subset of *S* (denoted as *E*) [8]. For example, the event of rolling a die that landed on one of the prime numbers can be written as $E = \{2, 3, 5\}$. Two events, *E* and *F*, can be considered mutually exclusive if they can't simultaneously happen ($E \cap F = \emptyset$) [8].

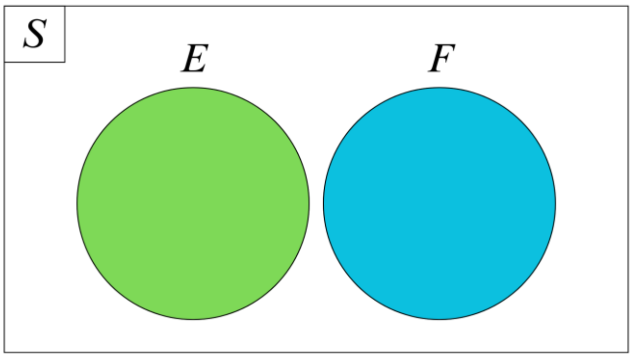

Fig. 5. Venn diagram representation of two mutually exclusive events.

Counting how many members does an event has also relies heavily on combinatorics concepts. For example, calculating how many members does an event of drawing cards with all of the same suit has when drawing 8 cards from a 52 card deck. Since each suit has the same amount of cards each, calculating for one suit is enough to represent each suit. Each suit has 13 different cards. So to draw 8 cards of the same suit, select 8 cards from 13 different cards, or can be written as $C(13, 8)$. Since there are 4 suits in total, the amount of member said event is $|E| = C(13, 8) \times 4$.

With two of those definitions covered, the concept of probability can be explored. In this paper, only probability in sample space with equally likely outcomes is needed (each member of sample space is equally likely to happen). The probability of any event (*E*), when the sample space (*S*) is with equally likely outcomes, according to [8], can be calculated using

$$P(E) = \frac{|E|}{|S|} \quad (6)$$

III. Analysis

A. *Problem Statement*

There are a lot of ways a *Balatro* run can pan out, even only in the first hand of the first round. Assuming the player choose to face the small blind at ante 1, there are some combination of cards, which will be referred as playing hand, that can be played to "one-shot" the blind (using only one hand to beat the blind), since the threshold of the small blind is considerably low (only 300). This paper will analyze those "winning hand" and calculate the probability of said hand appearing in the first hand of the first round of a *Balatro* run. Additionally, this paper will also analyze the average score of every possible first hand if the player decides to play the most scoring hand available.

B. *Calculating Every Possible Winning Hand*

A playing hand is considered a "winning hand" if the score granted from it equal or exceeds the required score (for this case, 300). Not many playing hands are considered a winning hand in this case even in the first round of *Balatro*. A winning hand most likely uses strong poker hand with high base chips and mults, such as full house, straight, straight flush, etc. It also most likely uses high ranking cards that can grant more chips than others. Since playing hand consist of up to 5 cards from 52 cards in deck, the amount of playing hand can be calculated using combinatorics concept, which is

$$|S| = C(52,5) + C(52,4) + C(52,3) + C(52,2) + C(52,1)$$

$$= 2893163 \quad (7)$$

Fig. 6. An example of winning hand

Below are every poker hand and its analysis whether certain poker hand can create winning hands, assuming there are no certain deck effects, no certain stake effects, and the deck contains cards that are the same as the standard *Poker* deck (52 unique cards that consist of 13 ranks for each of 4 suits).

- **Straight flush:** since the base chip and mult are already exceeds the required score when calculated ($100 \times 8 = 800$), every combination of a straight flush is a winning hand. To calculate, pick 5 ranks from 13 ranks available that can form a straight hand and then multiply the number of every possible outcome with 4 (since there are 4 suits in the deck). To simplify the counting process, focus only at the start of a straight (the lowest rank) that has 4 ranks above it. There are only 9 ranks that satisfy the requirements (2, 3, …, 10) plus one additional rank, since rank ace, two, three, four, and five can create a straight hand. The amount of possible straight flushes can be calculated using this formula:

$$|E_{sf}| = 10 \times 4 = 40 \quad (8)$$

- **Four of a kind**: the base chip and mult this poker hand provides also already exceeds the required score when calculated ($60 \times 7 = 420$). That means, every combination of a four of a kind hand is considered a winning hand. To calculate, pick a rank from 13 ranks available and then multiply every possible outcome with how many possible fifth card that can be picked from the remaining cards in deck (can also pick none to create a four-card playing hand). The amount of four of a kind playing hand can be calculated using this formula:

$$|E_{fk}| = C(13, 1) \times C(52 - 4 + 1, 1) = 637 \quad (9)$$

- **Full house:** this poker hand's base chip and mult can't exceed the required score when calculated ($40 \times 4 = 160$). But, scored cards can provide additional chips necessary to exceed the required score. A full house playing hand is a winning hand when the chips provided from cards combined is at least 35. With that in mind, there are 92 combinations of two ranks that make a pair and a three of a kind each (from {two, two, ace, ace, ace} to {ace, ace, five, five, five}). Each card can also use arbitrary suits if not taken by the other same-ranking card. So, the suit choice can be represented as picking 2 suits from 4 suits (for the pair) and picking 3 suits from 4 suits (for the three of a kind). Because of that, the amount of full house that is considered a winning hand as follows:

$$|E_{fh}| = 92 \times C(4, 2) \times C(4, 3) = 2208 \quad (10)$$

- **Flush:** same as full house, this poker hand's base chip and mult can't exceed the required score ($35 \times 4 = 140$) without the help of additional chips from cards in playing hand. A flush playing hand is a winning hand when the chips provided from cards combined is at least 40. It's really complex to calculate it using combinatorics concepts. So, the calculation is done by a program that can be accessed using this link: https://drive.google.com/file/d/1_mhsJoPn1nFl9w2URAIx9lg9b9-gl_5N/view?usp=drive_link. There are 1520 possible combinations of flushes that are winning hands. This number can be represented in an equation:

$$|E_f| = 1520 \quad (11)$$

- **Straight:** also same as full house, this poker hand's base chips and mult can't exceed the required score ($30 \times 4 = 140$) without the help of additional chips from cards in playing hand. A straight playing hand is a winning hand when the chips provided from cards combined is at least 45. The least amount of score from a straight that is a winning hand is if the starting rank of a straight is eight ({eight, nine, ten, jack, queen} will score $8 + 9 + 10 + 10 + 10 = 47$, the lowest amount of chips from cards). Because of that, there are only three possible starting rank of a straight to create a winning hand (eight, nine, and ten). The suit for each card in playing hand is also arbitrary. So, for each card, pick 1 suit from 4 suits available. Additionally, because 5 cards with the same suit in a straight will be considered a straight flush, after the calculation, subtract the amount of straight flush combinations. The amount of straight flush combinations is 3 times 4 (only 3 possible ranks of starting straight and 4 suits). The calculation is as follows:

$$|E_s| = 3 \times \left(C(4, 1)\right)^5 - 3 \times C(4,1) = 3060 \quad (12)$$

- **Three of a kind:** There are no possible way to create a winning hand by using three of a kind. Even with the highest-ranking card, which is ace, the three of a kind playing hand still falls short for the required score $((30 + 11 \times 3) \times 3 = 189$. Because of that, the amount of possible three of a kind playing hand that is a winning hand is zero.

$$|E_{tk}| = 0 \quad (13)$$

- **Two pair:** Even with the two of the highest-ranking card, which is king and ace, a two pair playing hand still falls short for the required score $((20 + 11 \times 2 + 10 \times 2) \times 2 = 114)$. Therefore, the amount of possible two pair playing hand that is a winning hand is zero.

$$|E_{tp}| = 0 \quad (14)$$

- **Pair:** Even with the highest-ranking card, which is ace, a pair playing hand still falls short for the required score $((10 + 11 \times 2) \times 2 = 62)$. Therefore, the amount of possible pair playing hand that is a winning hand is zero.

$$|E_p| = 0 \quad (15)$$

- **High card:** Even with the highest-ranking card, which is ace, a high card playing hand still falls short for the required score $((5 + 11) \times 1 = 16)$. Therefore, the amount of possible high card playing hand that is a winning hand is zero.

$$|E_h| = 0 \quad (16)$$

With all poker hands analyzed, we can calculate how many combinations of a playing hand that is a winning hand. Sum rule should be used to calculate this, since each poker hands can't intercept with other poker hands and doesn't occur at the same time.

$$|E|$$

$$= |E_{sf}| + |E_{fk}| + |E_{fh}| + |E_f|$$

$$+|E_s| + |E_{tk}| + |E_{tp}| + |E_p| + |E_h|$$

$$= 40 + 637 + 2208 + 1520 + 3060 + 0 + 0 + 0 + 0$$

$$= 7465 \quad (17)$$

Those calculations can actually be done by a program that can simulate every possible playing hand (for example, the flush poker hand is calculated using said program because it is too complex to count). Said program can be downloaded with this link: https://drive.google.com/file/d/1_mhsJoPn1nFl9w2URAIx9lg9b9-gl_5N/view?usp=drive_link. The program will output as the following:

```
Hand Count: 2598960
Win Count: 7452
Avg score 45.734962
SF: 40
FK: 624
FH: 2208
F: 1520
S: 3060
TK: 0
TP: 0
P: 0
H: 0
```

Fig. 7. The output of a program that simulates every possible playing hand (SF: straight flush win, FK: four of a kind win, FH: full house win, F: flush win, S: straight win, TK: three of a kind win, TP: two pair win, P: pair win, H: high card win).

At first, it seems that the hand count, win count, and the full house win count is different than the calculation. The reason is that the program only simulates each possible five-card playing hand, not each possible playing hand that can consist of up to 5 cards. The hand count is different from calculation because the program only simulates five-cards playing hand (which is $C(52, 5)$ instead of in (7)). The five-card winning hand doesn't change at all because they are all accounted for in the program. For the four of a kind, because a card is arbitrary, the program didn't account for four-hand playing hand.

Some interesting information can be found from the analysis.

- The amount of winning hand combinations is far less than the amount of every combination of playing hand (refer to (7) and (17)). Approximately only 0.26% of playing hand is a winning hand.
- There are more full house winning hand than flush winning hand (refer to (10) and (11)), even though full house has more base chips than the flush poker hand. Because of that, it's generally more likely to get a full house winning hand rather than a flush winning hand.
- The poker hand that have the most winning hand is straight, 3060 to be exact (refer to (12)). So, the winning hand is most likely a straight if there's a winning hand at all.
- Three of a kind, two pair, pair, and high card poker hand doesn't have even a single winning hand (refer to (13), (14), (15), and (16)). If the player decides to "one-shot" the small blind, it's generally better to look for a more stronger poker hand by using discards.

C. Simulating Every Possible First Hand

The first hand in the first round of *Balatro* consists of 8 cards that are drawn from the deck at the start of the round. The order of those drawn cards doesn't really matter. Because of that, calculating the number of how many possible first hand can be done using the combination concept, picking 8 cards from 52-card deck. The calculation can be done with this equation:

$$|S_2| = C(52, 8) = 752538150 \tag{18}$$

A hand is called a winning draw if it consists of at least one winning hand. The first idea is to calculate the amount of winning draw by using previous, winning draw, calculations, by picking 3 more random cards available on the remaining deck to create a hand. But, complication arise when the hand consists of two or more winning hand (for example, {(two, diamond), (three, diamond), (four, diamond), (five, diamond), (six, diamond), (six, club), (six, heart), (six, spade)} consists of a straight flush and a four of a kind). It's subjectively more complicated to calculate since it is needed to determine every possible combination of two or more winning hands that can occur at the same time in a hand. Therefore, a program is needed to calculate every possible winning draw by doing a simulation on every possible first hand.

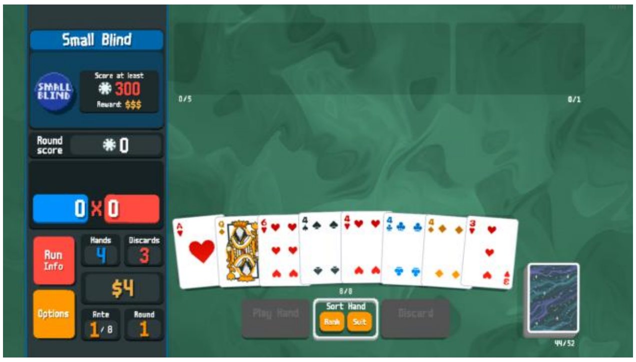

Fig. 8. An example of winning draw

Said program can be downloaded using this link: https://drive.google.com/file/d/1_mhsJoPn1nFl9w2URAIx9lg9b9-gl_5N/view?usp=drive_link. The program essentially iterates every possible first hand and tries to find the best playing hand. If the chosen playing hand is a winning hand (can achieve scores greater or equal than the required score, which is 300), it will count it as a winning draw. It will also accumulate scores that are granted by the best playing hand for each first hand iteration to calculate average scores later. The following is a screenshot of the output of said program.

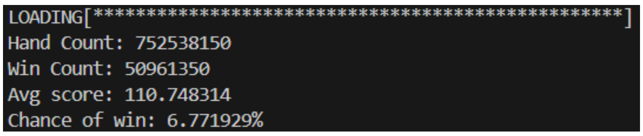

Fig. 9. The output of a program that simulates every possible first hand.

Note that the hand count corresponds to the calculation before (refer to (18)) that means it most likely iterated all possible first hand. There are some interesting information that can be inferred from that output of the program.

- Even though the ratio of the amount of winning hand to the amount of every possible playing hand is only 0.26%, the ratio of the amount of winning draw to the amount of every possible first hand is approximately 6.77% (by dividing hand count and win count). That ratio can be inferred as the probability of winning the first round by only using one hand, since it's a event size (when it's the winning draw) divided by a sample size (every possible first hand) after all.
- The average score of every first hand possible, if the player decides to play the best playing hand possible on the first turn, is approximately 110.74.

IV. Conclusion

There are several key points to point out from the analysis that has been made. First, there are 7,633 possible winning hand (playing hand that can "one-shot" the small blind at ante 1) in total, with the poker hand that has the most amount of winning hand is straight. Second, the chance of drawing a winning draw (first hand that contains at least one winning hand) as the first hand in the first round of *Balatro* is about 6.77%, so, the player most likely needs to discard some cards to draw a winning hand in the first round. Third, the approximate average score of each possible first hand, if the player decides to play the best playing hand that is available in hand, is 110.74. Hopefully, this paper can be a great resource either for reading or for researching.

V. Appendix

Program's source codes and executables can be downloaded from the link below: https://drive.google.com/drive/folders/1BSNRCeIC48aIGEMAqMt6fs4ohZPzTNCH?usp=drive_link.

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PERNYATAAN

Dengan ini saya menyatakan bahwa makalah yang saya tulis ini adalah tulisan saya sendiri, bukan saduran, atau terjemahan dari makalah orang lain, dan bukan plagiasi.

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