Preflop Trainer

A Training Tool for Poker Players

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Abstract

The game of Poker is a card game that involves gambling, strategy and skill. It is a game of imperfect information, where the player must consider probabilistic knowledge, risk assessment, and possible deception, not unlike decisions made in the real world.

The round of betting that occurs at the beginning of a poker hand is known as the *pre-flop.* In this stage, players look down to see their *hole cards* and make a decision on whether to fold, call or raise if applicable. This decision is one of the most crucial elements of poker.

Deciding starting cards is a practice that requires knowledge, experience and discipline. In the poker variant *Texas Hold'em,* there are 169 possible starting hands, making strict rules regarding pre-flop play possible. While in *Pot-Limit Omaha,* there are exactly 16,432 possible starting hands, making pre-flop play a much more sophisticated process.

This project *(Preflop Trainer)* aims to improve the experience of deciding the playability of a hand, by creating a training tool to help a poker player refine their range of starting hands. A player should be able to analyse a large volume of hands in a short amount of time, and receive instant feedback on each hand as to where it should fall in their range of hands.

Preflop Trainer is an attempt to, over time, teach a poker player the correct range of starting hands for a given position.

Declaration of Originality

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_____ _____

Acknowledgements

“No matter how much you may want to think of Hold’em as a card game played by people, in many respects it is even more valid to think of it as a game about people that happens to be played with cards.”

- Phil Hellmuth, 14-time winner of the World Series of Poker

I would like to thank several professional poker players. I would like to thank Phil Hellmuth and Phil Ivey, for demonstrating expertise play and Doug Polk for his thoughtful commentary. For improving my knowledge of Pot-limit Omaha, I would like thank Phil Galfond, Jeff Hwang and especially Fernando Habegger. For teaching the incredibly intricate bluffs, Tom Dwan and Phil Laak. There are many other players I would like to thank but the previously mentioned will have to suffice.

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Table of Contents

Table of Figures/Formulas

Glossary of Poker terminology[1]

Bet A specified amount of chips wagered during the play of a hand.

Bluff A bet made with a hand that is mathematically unlikely to be the best hand.

Board The set of community cards in a community card game.

Call To match a bet or raise.

Community Card A card which appears on the board that can be used by any player.

Equity The equity a player can expect to gain due to the opponent folding to his or her bets.

Flop The dealing of the first three community cards and those cards themselves.

Fold To discard one's hand and forfeit the pot.

Open To bet first.

Pre-flop The round of betting that occurs before the flop has been dealt.

Pot The total amount of money that all participating players wager in a given hand.

Position The order in which players are seated around the table.

Range The set of cards that a player considers an opponent might have.

Raise To increase the size of an existing bet in the same betting round.

River The fifth (and final) card of five community cards dealt on the board.

Turn The fourth card of five community cards dealt on the board.

1. Introduction

A good understanding of the game of poker, poker strategy and poker dynamics are not required to understand the motivation behind this project. Simply, all that is required to understand this project is that at the start of a game of poker, some players hold hands are that better than others.

1.1 Goal

The goal of this project was to implement a training tool for poker players, to help them better choose their starting cards. The preflop betting stage is extremely important across all variants of poker, particularly important in Pot-Limit Omaha (PLO) and Pot-Limit Omaha Hi/Lo (PLO8).

1.2 What kind of game is Poker?

It is possible to draw many comparisons to the game of poker. One such comparison is to the game blackjack. Poker and blackjack are both are played in casinos, and involve a mixture of luck and skill. Both benefit from a sound theoretical knowledge of the game and successful play involves making the optimal play as often as possible.

Yet, poker is nothing like blackjack. In poker, you play against other players, not against the house. In addition, the strategic scope of poker is far larger. A person with a good memory could virtually become a perfect blackjack player with comparatively little study. While in poker, there is no such thing as a perfect player.

Another comparison is to the game of chess. Both chess and poker involve deep strategy and careful analysis. Both require

you to outwit your opponent, taking both technical and human elements into consideration.

Yet, poker is nothing like chess, either. Chess is a game of perfect information, where players know the exact state of play at all times. There is little scope for deception or misrepresentation. Poker, on the other hand, is a game of imperfect information, where each opponent is attempting to discern what his or her opponents are holding.

Chess also involves no luck. The winner of the game is entirely determined by who plays the best moves. In poker, there are no guarantees, at least in the short term. The luck element rules that even over a reasonable number of hands, one can play well and lose, and indeed, play badly and win.

The key to understanding what kind of game poker is, is to look at the ways in which it is like chess, and the ways in which it is like blackjack, and the ways in which it is like neither.

1.3 Rules of Play

A *hand* of Texas Hold'em begns with the *pre-flop*. Each player is dealt two *hole cards* face down, followed by the first round of betting, which is started with two forced bets called the *small blind* and the *big blind*. Three community cards, collectively called the *flop*, are then dealt face up on the table, and the second round of betting occurs. On the *turn*, a fourth community card is dealt face up and another round of betting ensues. Finally, on the *river*, a fifth community card is dealt face up and the final round of betting occurs. The players still active in the game at that time reveal their two hole cards for the *showdown*. The best five-card poker hand formed from

each player's two private hole cards and the five public community cards wins the pot. If a tie occurs, the pot is split.

Texas Hold'em is typically played with 6 to 9 players. In general, when it is a player's turn to act, one of three betting options is available: *fold*, *check/call*, or *bet/raise*. The betting option rotates clockwise until each player has matched the current bet, or folded if there is only one player remaining (all others having folded) that player is the winner and is awarded the pot without having to reveal their cards.

1.4 Poker Strategy & Sample Hand[2]

To illustrate some of the decisions one must face in Hold'em, this is a presentation of a sample hand, with some typical reasoning a good player might go through. This hand is relatively basic, in order to make the example easier to follow. Many complex interactions can contribute to much more difficult situations, but it is hoped that this example will suffice to demonstrate some of the strategic richness of the game The game is €5-€10 Texas Hold'em with nine players. We are "on the button" meaning that we will be the last to act in each betting round, which is an advantage. The two players to the left of us post the small blind (€5) and the big blind (€10), and the cards are dealt. The action begins with the player to the left of the big blind, who calls €10 (we will refer to this player as "EP" for "early position"). The next three players fold (throwing their cards into the discard pile), a middle position player (MP) calls €10, and the last player folds.

We are next to act and have 7♦ 6♦. A strong poker player would know that this is a reasonably good drawing hand, which should be profitable to play for one bet from late position against several players. This would not be a good

hand to call a raise with, or to play against only one or two opponents. From previous hands played, we know that EP is a *tight* (conservative) player. We expect that EP probably has two big cards, since he called in early position (but didn't raise, making large pairs highly unlikely for this particular player). From experience, we have observed that MP is a *loose* player, who sees the flop about 70% of the time, so he could have almost anything (eg any pair, any two cards of the same suit, or even a hand like 6♠ 4♥). The small blind is an extremely tight player who will probably fold most hands rather than calling another €5. The big blind almost always defends her blind (i.e. she will call a raise)

A raise in this situation, for deceptive purposes, is not completely out of the question. However, it would be inappropriate against this particular set of opponents (it might be more suitable in a game with higher limits). We call the €10, the small blind calls, and the big blind checks.

The flop is Q♠ 7♥ 4♦. We have *second pair* (connecting with the second largest card on the board) for a hand of moderate strength and moderate potential for improvement. If we do not currently have the best hand, there are five direct outs (outcomes) that can immediately improve our hand (7♠ 7♣ 6♠ 6♣ and 6♥). We also have some indirect flush and straight potential, which will come in about 7% of the time (73 out of 990 outcomes (43 flushes and 30 straights)), and can be treated as roughly three direct outs. The board texture is fairly *dry*, with only a few possible straight draws, and no direct flush draws. Therefore, any bets by the opponents are likely to indicate a made hand (eg. a pair) rather than a *draw* (a hand where additional cards are needed), unless they are a chronic bluffer. An expert player wouldn't actually need to go through this thought process - it would simply be known the moment

the flop hits the table, through experience and pattern recognition. Both blinds check, EP bets, and MP folds.

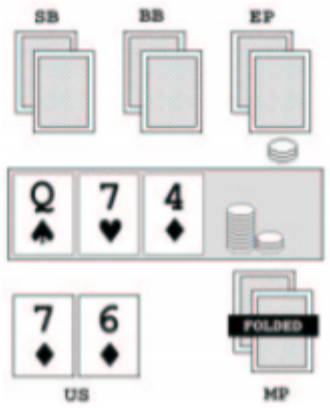


Figure 1: After the flop.

There is €60 in the pot, and it will cost us €10 to call. We believe the bettor seldom bluffs, and almost certainly has a Queen, given his early position preflop call. The small blind is known to *check-raise* on occasion, and might also have a Queen, but is more likely to have a poor match with the board cards, because he is highly selective before the flop. We have never observed the big blind check-raising in the past, so the danger of being trapped for an extra bet is not too high. We must also consider that his second card is reasonably good, perhaps a ten or a jack.

If we play, we must decide whether to raise, trying to drive the other players out of the hand, or call, inviting others to call also. If there was a good chance of currently having the best hand, we would be much more inclined to raise. However, we feel that chance is relatively small in the current situation. We might also want to drive out other players who are looking to hit the same cards we want, such as 5♣ 3♦, which needs a 6 to make a straight against our two pair. However, the added equity from having an extra bet in the pot is normally greater

than the risk of shared outs, so we are happy to let the blinds draw with us against the bettor.

From our previous study and experience, we know that calling in this situation is a small positive expectation play, but we still cannot rule out the possibility of *raising for a free-card.* If we raise now, we may induce the bettor to call and then check to us next round, when we can also check and get a second card for "free" (actually for half-price). We need to assess the likelihood that EP will re-raise immediately (costing us two extra bets, which is a very bad result), or will call but then bet into us again on the turn anyway (costing us one extra bet) Since we do not feel we have much control over this particular player, we reject the fancy raise maneuver, and just call the €10. Both of the blinds fold, so we are now *heads up* (one-on-one) with the bettor. Despite the many factors to consider, our decision is made quickly (normally within one second when it is our turn).

The turn card is the 5♥ and EP bets. The 5♥ gives us an open-ended draw to a straight, in addition to our other outs. The words *open-ended* indicate that we have four cards to a straight, and need an 8 or a 3 to complete our straight. In terms of expected value, this is essentially a "free pass" to the river, as we now have a clearly correct call of €20 to win €90. However, we again need to consider raising. This opponent will probably give us credit for having a very strong hand, since the 5♥ connects for several plausible two pair hands or straights. We could also be slow-playing a very strong hand, like a set (three of a kind using a pocket pair, such as 4♣ 4♦). Since we're quite certain he has only one pair, this particular opponent might even fold the best hand, especially if his *kicker* (side-card) is weak. At the very least, he will probably check to us on the river, when we can also check, unless we improve

our hand. Thus we would be investing the same amount of money as calling twice to reach the showdown, and we would be earning an extra big bet whenever we make our draw. On the other hand, we don't necessarily have to call that last bet on the river (although if we fold too often, we will become vulnerable to bluffing). We decide to make the expert play in this situation, confidently raising immediately after his bet. He thinks about his decision for a long time, and reluctantly calls.

The river card is the 5♠ which *pairs the board* and our opponent immediately checks. We know that he is not comfortable with his hand, so we can consider bluffing with what we believe is the second-best hand. From our past sessions we know that once this player goes to the river, he will usually see the hand through to the end. In effect, his decision after our raise was whether to fold, or to call two more bets. Since a bluff in this situation is unlikely to be profitable, we stick to our plan and check. He shows Q♣ J♣, we say "nice hand", and throw our cards into the discard pile.

Figure 2: Our hand versus EP after the river.

1.5 Table Image

Consider the sample hand shown previously. We must consider what effect this hand has had on our *table image*, in anticipation of how the players at the table will react to our future actions. The better players might have a pretty good idea of what we had (a small pair that picked up a good draw on the turn), and won't make any major adjustments to their perception of our play. Our opponent, EP, is more likely to call us down if a similar situation arises, so we might earn an extra bet on a strong hand later. Weaker players may think we are a somewhat wild gambler, so we expect them to call even more liberally against us. This reinforces our plan of seldom bluffing against them, but betting for value with more marginal hands.

1.6 What is the Pre-flop stage of Poker?

The preflop stage in poker is the round of betting that occurs at the beginning of a hand, before the flop has been dealt. Players in turn look down at their hand and make a decision on whether to fold, call or raise if applicable. Here, players must decide if their hand is strong enough to play. This decision is not an easy one, and varies in complexity across poker variants.

While played the same way, *No Limit Hold'em* and *Pot Limit Omaha* differ greatly in pre-flop strategy. With there being only 169 possible hands in NLHE, it is fairly simple to come up with a strategy for each playable hand, for each given position.

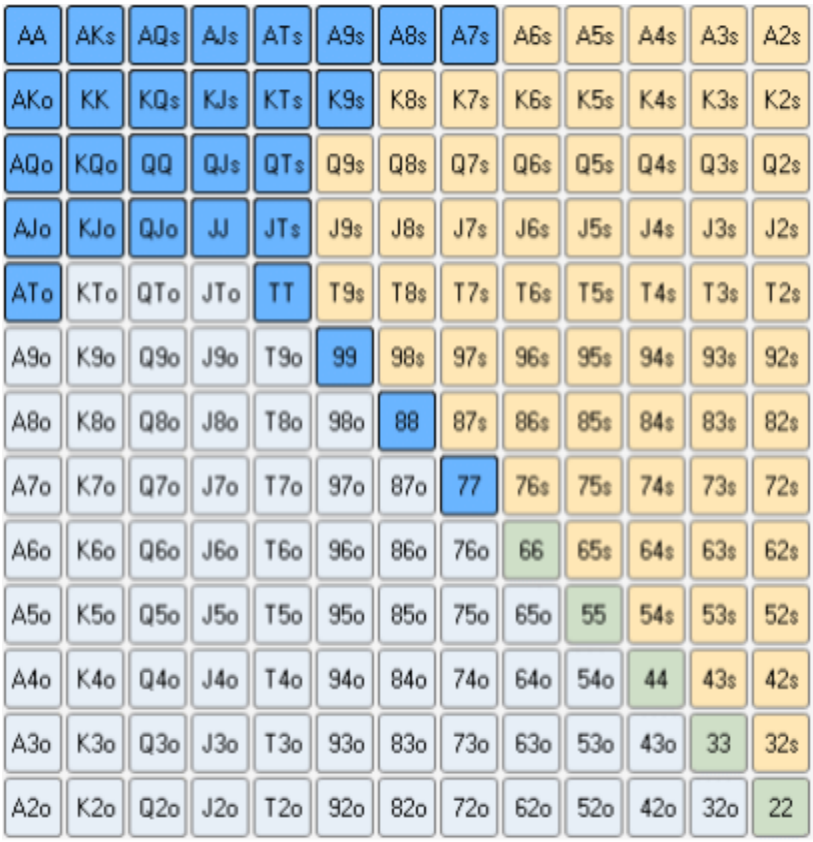


Figure 3: All possible starting hands in NLHE.[3]

However, starting hands in Pot-Limit Omaha are grouped by structure.[4] With so many possible 4-card combinations it is actually the suits, closeness of the cards and pairs as well as the high card strength that makes the difference between a strong starting hand and a weak one. Add to this the fact that seemingly insignificant differences – for example a gap at the top end of your connected middle cards (eg. 8♥ 6♣ 5♥ 4♣) compared to a gap at the bottom end (eg. 7♥ 6♣ 5♥ 4♣) – make a huge difference and it is difficult to come up with some simple 'cut off point' between good and poor hands in the same way as is done in Holdem.

1.7 Live Poker vs Online Poker

In *live* poker (poker played in real life), the preflop stage can be much more strategic, as one can look at other players to pick up an indication of their hand strength. In fact, when your cards are first dealt to you, it is advisable not to look at your cards immediately, but to observe the other players looking at their cards. If you know (or strongly suspect) what other players are going to do, you may want to rethink the pre-flop actions you had in mind.

However, this does not mean there are no possible tells for online play. The most common one is a *timing tell* where by a player indicates the strength (or weakness) of their hand by responding quickly or slowly when it is their turn to act.

2. Analysis

2.1 Marketability

There is a substantial possibility for this tool to generate profit. Poker players generally have plenty of disposable income, and are more than willing to use this income to improve their poker game in any way possible.

Training courses are typically $99 a month, and one-on-one coaching can be upwards of $999 per session.

This tool could be locked behind a paywall, where once paid, unlimited use could be granted, or fixed use, for example one could allow someone to test themselves for 10,000 hands.

2.2 Texas Holdem vs. Pot-Limit Omaha[5]

Even the best Hold'em players can often make beginner errors when moving from Hold'em to Pot-Limit Omaha. The rules of the game are quite similar - however, there are two key differences between Hold'em and PLO. Players are dealt four cards instead of two, and to make a 5-card hand, players must use exactly two of the four cards they have been dealt. The betting is different too, where the maximum bet is the size of the pot (hence "pot-limit").

2.2.1 High Pairs

While two aces (AA) is the best possible hand in Hold'em, in PLO, it is very unlikely to win a pot unimproved against more than a single opponent. Players who are new to Pot-Limit Omaha often overvalue hands with AA in them. One of the marks of a good PLO player is being able to fold AA when they know they are behind. Unless one can get a substantial amount of big blinds in preflop, one should take caution with AA. The danger of betting so heavily preflop is that this tells the table what you hold and at the same time gives other players the correct implied-odds to outdraw you. High pair hands have dramatically increased equity when combined with straight possibilities and/or suited cards.

2.2.2 Combinations

Players will sometimes overlook the equity of coordinated cards preflop. For example, 7♥ 6♣ 5♥ 4♣ is actually a 49.3% favourite to win the pot pre-flop against A♣ A♠ 9♥ 2♦.

Players should realise that with four hole cards, there are six possible combinations of cards that can be used. The better the combinations - especially combinations that can make the the best possible hand - the better the hand is.

2.2.3 Closer Preflop equity in PLO

Following on from the sections on High Pairs and Combinations, there are no huge favourites preflop in PLO. Even the strongest starting hands, for example A♥ A♠ K♥ K♠, will only have approximately 65% equity against a single opponent.

With less of an edge preflop, combined with the pot-limit betting structure, makes Omaha much more of a post-flop game. The smaller bets early in a hand, in comparison to the potential bet sizes by the river, make Omaha a game of implied-odds, draws and post-flop maneuvering.

2.2.4 Draws and Made Hands

A draw is a hand that has high potential to become the best hand by the river. A made hand is a hand that already has a decent chance of winning - eg. a completed straight or an ace-high flush.

In the game of Hold'em, a made hand will usually be a strong favourite against a draw on the flop. However, in Omaha, a draw can have as much as 70% equity against a made hand such as trips. For example, a hand like A♣ A♠ 9♥ 2♦ (a made hand) on a flop of 5♥ 7♣ 8♥ can only have 31% chance to win against a drawing hand such as Q♥ J♣ T♥ 9♣. Even if the flop was instead A♥ 7♣ 8♥, giving the initial hand a set of aces, the hand only has 45% chance to win. These numbers may appear surprising, but not when considering the number of outs available to make a flush or a straight.

2.3 Existing Preflop Trainers

Application Name: **PLO Trainer** (https://plo-trainer.com/)

PLO Trainer is a preflop training tool for the poker variant Pot-Limit Omaha. Users “rank the hand” by estimating the raw equity of a random hand shown. A slider is used to select an equity between 0 and 100 percent (0 being worst, 100 being best). After clicking a “Check!” button they are then shown the exact equity of the hand and given a response of “Good”, “Alright” and “Nope” depending on whether their guess was respectively within 5, 15 or greater than 15 percent of the actual equity.

This approach is heavily flawed due to a fundamental error - players do not estimate the exact equity when deciding to play a hand. The decision to play a hand is binary - either play or don’t play a hand.

For an example of how this is flawed, while using the application one might estimate a hand with 10% to have an equity of 26%. They would then receive the worst possible result of “Nope”. This result is impractical. The difference between a hand with 10 and 26 percent equity is moot - in both cases, the hand is so bad that it would always be folded. Similarly, the difference between 85 and 100 percent equity is not worth evaluating - the hand is so strong that it will always be played.

3. Design

3.1 Introduction

Preflop Trainer was implemented in Python3, JavaScript and HTML.

The project used only in-built modules and no external libraries. The source code consisted of two HTML files with two corresponding JavaScript files, a CSS file, and two Python files. The Python files make up the backend while all other files make up the frontend.

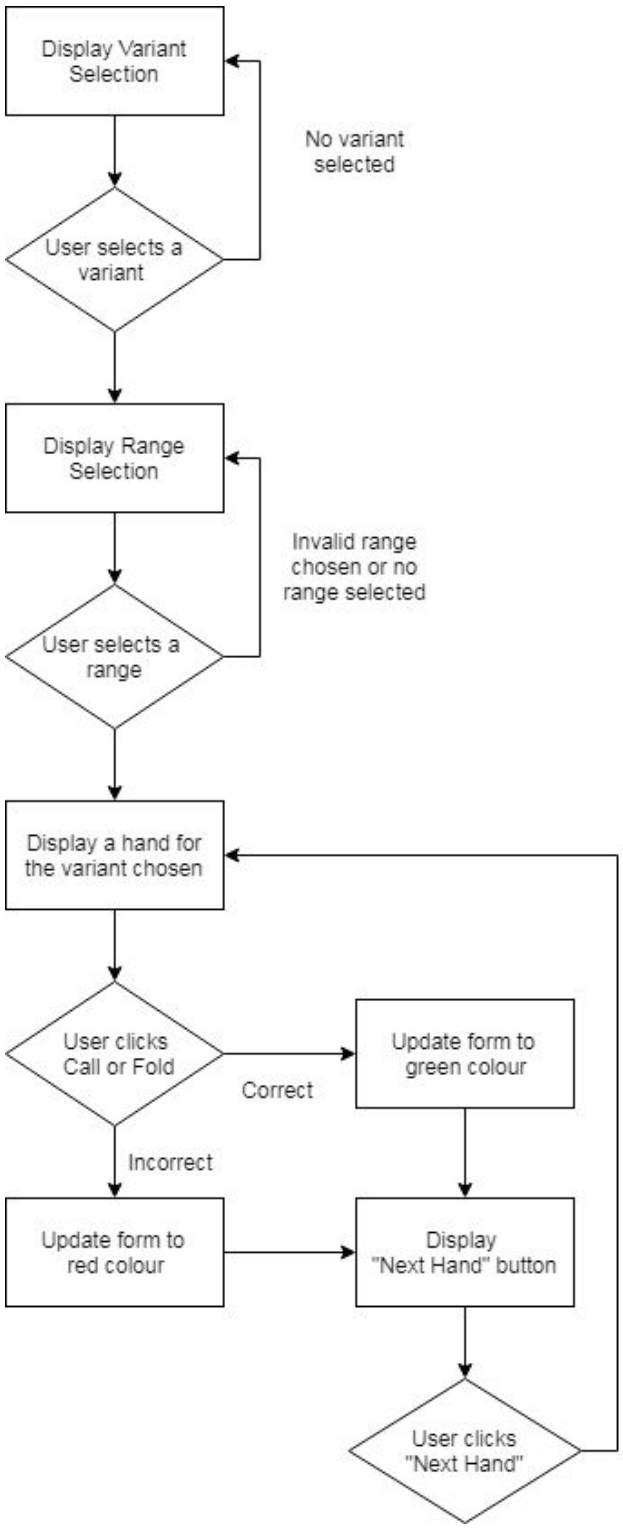
3.2 Standards[6]

The code within the project complies with PEP8 which layout standards for code style and layout specifically centred around the Python programming language.

3.3 Aesthetics

The overarching design philosophy for the layout of the application was to keep it simple. The user must give the application full attention, so it should not be “busy” and uneasy on the eye.

3.4 Flowchart of Operations



3.5 Frontend

The frontend for the project was a WWW webpage. This consisted of three components: the variant selection, the range selection and the hand display.

Figure 4: Flowchart of progression through the application.

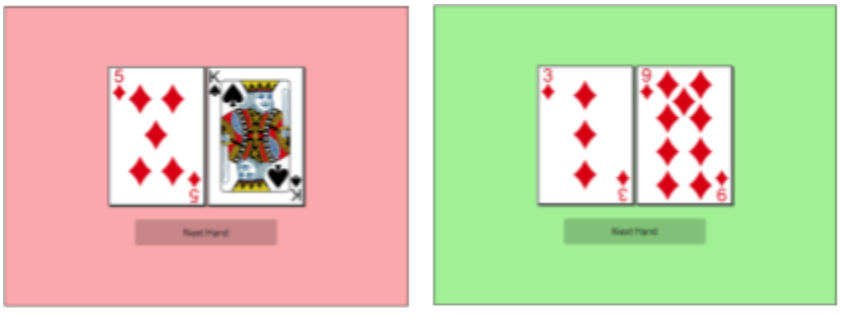
Since both the variant selection and range selection sections involved choosing a single item from a list of items, it made sense to use an checklist with radio buttons. A user simply has to click on their preferred variant and range, click *Next* and they have completed the prelude to actually training. The one exception to this is when a user selects a custom range, where they are also required to enter a number between 0-100 signifying their custom range. The entire process takes less than 30 seconds, which is an good usage of the user's time.

3.5.1 Landing Page

A landing page is a web page which serves as the entry point for a website or a particular section of a website. The landing page for Preflop Trainer is simply the variant selection page. The student would have liked to have created an introduction page with a brief summary on how to use the tool, but unfortunately this was not possible in the time permitted. Regardless, how to use the tool should be obvious to any competent poker player, so an introduction page was not a priority.

3.5.2 Hand Display

The page displayed after the variant and range selection forms are completed is the page which displays a hand. The design of this page was deliberately kept simple - there should be no distractions to the user. Two buttons are displayed, *Fold* and *Call* which are the boolean equivalent true and false in this case. The interface then responds by changing the background colour of the page to red or green.



Incorrect Response Correct Response

Figure 5: Possible responses after clicking Fold/Call.

3.5.3 Colour Considerations

Careful consideration was made in regard to the exact tone and hue of these colours. The red colour should not feel too punishing and the green colour should not feel overly rewarding. A feeling of satisfaction should not come from any one individual successful decision, but rather many successive correct decisions. Conversely, a negative feeling should not be invoked by any one incorrect decision, but consecutive incorrect decisions.

In addition, some research shows that males prefer “cool” colours while females prefer “warm” colours. Studies also show that approximately 86% of gamblers are male, with only 14% being female.[7] Since there is an overrepresentation of men in poker, there is likely an overrepresentation of men who will use this tool. As such, there was a bias toward “cool” colours in choosing the colour selection.

The colours were chosen using an online tool called *Paletton*. Paletton is a tool used to find colour combinations that work together well. Using this tool, I was able to find a red and green colour with the same hue and tone.

3.5.4 Different Displays

Figure 6: Different displays for each poker variant.

Depending on the variant chosen, a different number of cards will be displayed. There will be two cards displayed if the user selected the variant *Texas Hold'em,* four cards displayed if the user selected either *Pot-limit Omaha* variant, and five cards shown for *Big-O.*

The display of cards was accomplished using a clever combination of HTML and CSS. This will be explained further in **4.4 Displaying a Hand**.

3.6 Displaying Buttons

The display of buttons was intentionally kept simple. The buttons are large in size meaning they are easy to click. They have been given large, single-worded labels to directly indicate their function. Since the user will be moving their cursor from side-to-side clicking on either button, the distance between the buttons was kept small.

Figure 7: Fold and Call buttons.

The CSS-styling of the buttons was also relatively simple. A grey colour was chosen, as this stands out best against the white background. The tone of the grey was chosen to not be too light that it blended into the background, but not too dark that the labels could still be seen.

```
input[type=submit]{
    position: relative;
    appearance: none;
    background: rgba(0, 0, 0, .2);
    padding: .8em;
    width: 75%;
    border: none;
    cursor: pointer;
    outline: none;
    color: #0D0E0E;
    border-radius: 4px;
    transition: opacity .3s ease;

    margin-top: 5%;
    margin-left: 15%;
    margin-right: 10%;
}
```

3.7 Backend

The backend for this project consists of two Python files: *reader.py* and *format.py*. It also consists of the *orderings* folder. The two python files respectively read a file from the orderings folder and format the hand into a human-readable format.

3.7.1 reader.py

The purpose of *reader.py* was to take a file from the orderings folder and turn it into a dictionary of key-value pairs representing the strength for a hand and the corresponding hand itself. For example, a key-value pair from the dictionary might be {68:(K3)(T4)} which means a hand of that format, eg. K♥ T♣ 3♥ 4♣, is in the 68th percentile (ie. in the top 68% of all hands).

The file consists of four functions, *build*, *file_len*, *random_val*, and *convert_to_png.* The latter three functions respectively return the file length, select a random key-value pair, and append ".png" to each card in a list of cards. The most interesting of these functions is *build* which is shown below.

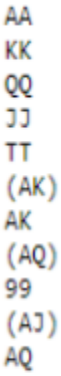
```
1.  def build(file):
2.      d = { }
3.      num_lines = file_len(file)
4.      file.seek(0)
5.      for index, line in enumerate(file, start = 1):
6.          perc = round(((index / num_lines) * 100) + 1)
7.          if perc not in d:
8.              d[perc] = []
9.          d[perc] += [line.strip()]
10.     return d
```

3.7.2 format.py

The purpose of *format.py* was to take a hand in the form presented in the *orderings* folder and convert it into a human readable format. This file relied heavily on the *choice* function imported from the *random.py* library. It consisted of two functions, *format,* which formatted the hand by appending a suit to each of the cards, and *jumble*, which went unused. The *format* function used a sophisticated method of choosing which card belonged to which suit. Initially there are four suits to choose from, and one of them is chosen at random for the first card. If the next card is suited, the same suit is appended, otherwise, the initial suit is removed from the list of possible suits to choose from and a new suit is chosen at random. This pattern continues until the last card in the hand is reached. The code for this function is given in **4.4 Random Hand Generation.**

There are different numbers of outcomes depending on the number of cards given, and the format they are given in. This is explained further in section **3.8 Possible Hands**.

3.7.3 Ordering files



Top 10 NLHE hands

Figure 8: The first ten lines of *holdem_6handed.txt*

Top 10 Omaha hands

Figure 9: The first ten lines of *omaha_hi_6handed.txt*

Shown in Figures 8 & 9 are the top ten hands for the *holdem_6handed.txt* and the *omaha_hi_6handed.txt* text files, which contain all possible hands for No Limit Hold'em and Pot-Limit Omaha respectively. The brackets represent suitedness, ie. one possible representation for (AK) is A♥ K♥ - but not, for example, A♠ K♥ which would be represented simply as AK.

Note that these figures may seem puzzling at first. For example, for the first two hands displayed in *Top 10 Omaha Hands* are aces with tens and aces with jacks. However, the hand with the tens ranks higher than the one with the jacks. This is simply because the program that was used to determine the rankings list runs on approximately 10 million iterations, and this is not enough to discere 16,000th of a difference in playing strength. However, the list is still sufficiently accurate for our purposes, since these hands will both rank in the 1st percentile.

3.8 Possible Hands

Since there are different numbers of starting cards for each variant, the number of hands possible varies between variants. It is important now to demonstrate the difference between number of possible startings hands and the number of unique starting hands. The number of possible hands is determined trivially using the choose formula:

$$possibilities = \frac{52!}{k!(52-k)!}$$

Formula 1: Possible hands.

where k is the total number of cards in a hand. The constant 52 represents the number of playing cards.

The formula to calculate the number of unique starting hands is more complex. First, consider that (in Hold'em) there are three types of hands: pairs, suited non-pairs, and unsuited non-pairs. There are exactly 6 combinations of any pair, for example two aces can be A♥A♦, A♥A♣, A♥A♠, A♦A♣, A♦A♠, and A♣A♠. This is because for four possible cards, choosing two of them results in $4\,C\,2 = 6$. There are 4 combinations of suited non-pairs, one for each suit. There are 12 combinations of unsuited non-pairs. The number of pairs, suited non-pairs and unsuited non-pairs make up the three variables for calculating the number of unique starting hands.

In PLO, there are five types of hands. In Big-O, there are six types of hands. The number of types of hands grows exponentially as the number of cards used increases.

4. Implementation

4.1 Libraries & Technologies

4.1.1 random

The random Python Library was used to choose a random starting hand. In particular, the *choice* function was used to choose a random hand from a list of hands, and the *shuffle* function was used to mix the order of cards in a hand.

4.1.2 os

The os Python Library was used to concatenate strings together to form a file directory.

4.1.3 cgi

The cgi Python Library (Common Gateway Interface) was used to gain access to submitted form data. Particularly, the *FieldStorage* class was used.

4.1.4 cgitb

This Python Library contains a function which activates a special exception handler that will display detailed reports in the Web browser if any errors occur.

4.1.5 GitHub

GitHub was used for version control of the project and was crucial for the successful tracking of iterations as well as keeping track of the issues. For each significant change that was made to the project, a version of it was uploaded to GitHub.

4.1.6 Sublime Text 2

Sublime Text 2 was used as the text editor for this project. Sublime Text is a sophisticated text editor for code, markup and prose.

4.2 Ordering Files

Four files made up the orderings folder:

- *holdem_6handed.txt*
- *omaha_hi_6handed.txt*
- *omaha_hilo_6handed.txt*
- *omaha_5card_9handed.txt*

These files each contain all possible hands,
in order of their strength, for *Hold'em,*
Omaha hi, Omaha hi/lo and *Big-O*.

4.3 Random Hand Generation

A function was required to create a random hand. In order to adhere to the DRY coding principle (Don't Repeat Yourself), the function should be able to generate a random hand seamlessly for all poker variants.

Since there was already access to a list of all possible hands from the orderings folder, it made sense to create a function that could process any given hand from that list and turn it into the format required.

A hand from the orderings folder has two characteristics - it is ordered from highest (A) to lowest (2) and it uses brackets to denote suitedness. For example, in Pot-Limit Omaha, the hand AT93 denotes a hand with an ace, ten, nine and three, and all cards are different suits. An example of a hand with suitedness could be (AT)(93) where the ace and ten are of one suit and the nine and three are of another suit. Also possible is A(T93) where the ace is one suit and all other cards are of a different, same suit, or even (AT93) where all cards are of one suit.

You will note that different possible hands for each of the above examples. For instance, (AT)(93) could be used to represent A♥ T♥ 9♦ 3♦ but also used to represent A♦ T♦ 9♥ 3♥. The function should have no bias toward any particular suit or format ie. it should choose the suits randomly.

The following is the code that is used to generate a random hand.

```
def format(str):
    suit_list = ['h', 'd', 'c', 's']
    out = [ ]
    suited = False
    for char in str:
        if char == "(":
            suit = choice(suit_list)
            suited = True
            continue
        elif char == ")":
            suit_list.remove(suit)
            suit = choice(suit_list)
            suited = False
            continue
        elif not suited:
            suit = choice(suit_list)
            suit_list.remove(suit)
        char += suit
        out.append(char)
    return out
```

This code produces a list of strings which are then used to represent a random hand. For example, if the input string was (AT)(93) one output might be [“Ad”, “Td”, “9h”, “3h”]. The code parses the input string, character by character, to determine what each character represents.

4.4 Displaying a Hand

After generating a random hand, that hand needed to be displayed in a web browser. A folder was kept containing images for all cards, each named as minimalist as possible.

Figure 10: Images for cards.

A simple function was used to iterate through the list of cards for a hand and append them with ".png". Now, a list of strings representing a hand was created. All that was left was for a function to loop through this list and generate a HTML image tag for each string representing a card.

```
1.  for image in image_list :
2.          print('<img src="png-cards/' + image + '">')
```

4.5 Variant Selection

The first thing the user sees when they enter the project is the variant selection page.

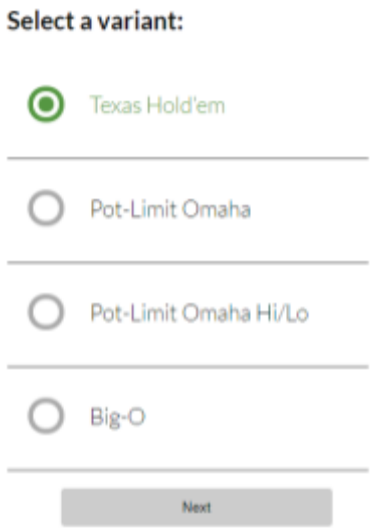


Figure 11: Variant selection.

The user is shown four options: *Texas Hold'em, Pot-Limit Omaha, Pot-Limit Omaha Hi/Lo* and *Big-O*. The options are placed in order of descending popularity - Texas Hold'em being the most popular poker variant. The first option is automatically selected, meaning the user can simply click *Next* immediately if their selection happens to be the most popular variant.

This list is a simple radio-button list. CSS was used to highlight the variant on mouse over, and the text of the selection becomes green (simulating highlighting) once the variant is selected.

4.6 Range Selection

The range selection is the second thing a user sees, after they have chosen a variant in *Variant Selection*.

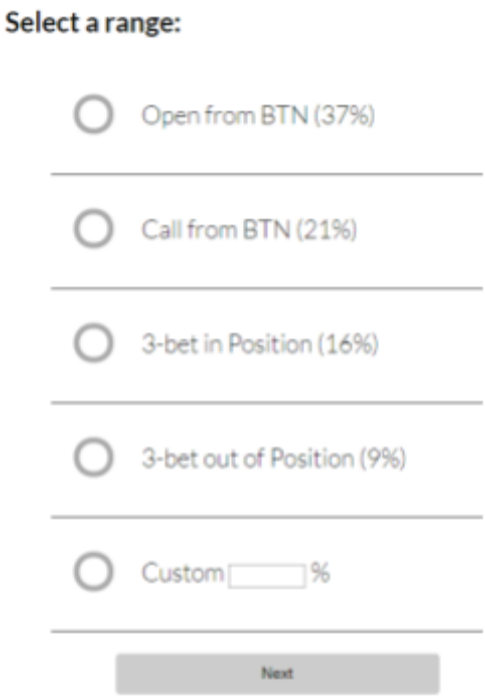


Figure 12: Range selection.

The user is shown five options, each option representing a situation in the preflop stage of poker, with a corresponding range for that situation. The range symbolises the percentage of hands that a user should be calling in that situation. For example, *Open from BTN* represents a situation where the user is on the Button position and all previous players have folded, and the percentage of hands that user should be making the opening bet for that hand ie. the top 37 percent of hands.

The same CSS was used for this radio-list and for *Variant Selection.* This was done deliberately to have consistent formatting across both radio-lists.

The final option is a custom option, where the user can select any range they wish.

```
<li>
    <input type="radio" name="range" id="E-option" value="Custom">
    <label for="E-option"> Custom
        <input type="text" id="custom_range" size=5 /> %
    </label>  <div class="check"> <div class="inside"> </div>
</div>
</li>
```

This requires two input tags, an input for the radio button to select *Custom* and an input for a value for the range.

Some validation is needed to ensure that the user inputs a positive whole number between 0 and 100, and also to prevent JavaScript injection attacks.

5. Evaluation

5.1 Importance

There are few tools available to train your preflop skills. Most players learn good preflop principles through sheer volume of hands played. The project is a way of expediting this learning process, allowing a user to test their knowledge by examining approximately 2000 hands per hour. Given there are only 169 unique hands in Hold'em, a user training their knowledge of this variant can very quickly master the entire preflop range.

5.2 Survey

An informal survey was conducted among several of the student's friends who were poker players. Many found the tool to be interesting. Some were critical of the fact that it gives an overly simplified version of the preflop selection process. Overall, most said they would continue to use it to improve their preflop skills.

5.3 Result

The final version of the application worked successfully. The user can repeatedly test their knowledge of the preflop stage of poker by evaluating hands for given positions. Overall, the project was a huge success and was showcased on the Project Open Day, impressing several people who were interested in it. However, there were still a number of things which the student would have liked to implement. These are discussed in the following section, **6.1 Possible extensions**.

6. Conclusions

6.1 Possible extensions

There are a number of possible extensions to this project. The most promising one would have been to add a scoring function to represent performance.

6.1.1 Scoring function

Users would receive feedback in terms of a positive or negative numerical score that would be positive or negative depending on whether they answered correctly or incorrectly. The size of the score (or penalty) would be dependant on how “difficult” the decision was. Difficulty here would be represented by how close to the range the hand displayed was. For example, if a hand in the top 21st percentile was correctly folded for a range of top 20%, the user would receive a huge increase in their score. Similarly, if a hand in the top 19th percentile was called, they would receive the same, large score. I found it difficult to define an exact formula for this, but it would be based on a shifted normal distribution, where the y-axis denotes score value and the x-axis represents how close the range is.

Figure 13: Normal distribution curve.

6.1.1 Non-binary responses

In the application, users select *Fold* or *Call* which is an essentially binary equivalent of true/false.

It would have been interesting to attempt to implement a feature where users would use a slider function to select a confidence interval between 0 - 100%. For example, 64% - indicating that they would *Call* 64% of the time, and therefore *Fold* 36% of the time.

In poker strategy, this is known as playing a *mixed strategy*. Playing a mixed strategy is known to be the optimal playing style. This may seem surprising - this is essentially saying that there is an element of randomness to the way the best poker players play. This strategy strives to make each decision at a certain frequency (e.g. you must call with at least 33% of the hands in your range when you're getting 2-to-1 pot odds).

There are many different ways to harness this randomness. My personal method is to use my electronic watch, where for example, if I was faced with a decision that I must call 30% of the time, I would call if I looked at my watch and saw a 1, 2 or 3 in the right side of the seconds hand. Since I do not know what the exact second is, this method is essentially simulating randomness.

Implementing the above would have required a significant rework of most of the code. In the case of PLO, it would require 16,000 hands * 4 positions = 64,000 additional entries to the *.txt* file. There would have to be additional logic that scored the hand in relation to the actual percentage.

6.2 Final Words

I very much enjoyed working on this project. The topic itself, poker, is one I have much experience with. I have been playing poker almost everyday for the last four years, and this project has allowed me to combine both my college work and a personal hobby.

During the course of the project, I learned quite a lot about Python and Javascript, and improved my own preflop game. I learned not only this, but also improved my investigative and research skills. This project tested my knowledge of web programming but has proved to be very beneficial in the long.

After completing this project, I am keen to develop another poker tool that will contribute to the poker community. Having this kind of motivation to keep developing the application and learning new technologies can only have a positive effect on personal growth as a Computer Science student.

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