Poker Hand Analysis Tool: Technical Documentation

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1 Introduction

This document provides a comprehensive explanation of the Poker Hand Analysis Tool, a Python program designed to analyze poker hands and provide statistical insights on hand strength. The tool can help poker players understand the relative strength of their hand at different stages of the game (flop, turn, and river) and make more informed decisions.

2 Program Overview

The Poker Hand Analysis Tool performs the following functions:

- Creates and manages a standard 52-card deck
- Allows users to input their hole cards and community cards (flop, turn, river)
- Calculates the best possible 5-card poker hand for each combination
- Ranks all possible hole card combinations for a given board
- Displays hand strength as a percentage
- Visualizes position distribution with highlighting for the user's hand
- Tracks how community cards affect hand rankings through each stage

3 Key Components

3.1 Card Representation

Cards are represented as tuples in the format `(value, suit)`, where:

- `value` is a string representing the card value ('2' through '10', 'J', 'Q', 'K', 'A')
- `suit` is a Unicode symbol representing the card suit ('♡', '♢', '♣', '♠')

The program uses the `colorama` library to display hearts and diamonds in red and clubs and spades in black, mimicking a real deck of cards.

3.2 Deck Creation and Management

The `create_deck()` function generates a standard 52-card deck with all combinations of values and suits. The deck is maintained as a list of card tuples, and cards are removed from the deck as they are dealt or selected.

3.3 Card Input Handling

The program allows both random card generation and manual input. For manual input, the `parse_card_input()` function validates user input and converts text descriptions (e.g., "A hearts" or "10 s") into the internal card tuple format.

3.4 Hand Evaluation

3.4.1 Hand Ranking Algorithm

The `identify_hand_ranking()` function evaluates a 5-card poker hand and returns a tuple containing:

1. A primary rank value (1-10) representing the hand type:
    - 10: Royal Flush
    - 9: Straight Flush
    - 8: Four of a Kind
    - 7: Full House
    - 6: Flush
    - 5: Straight
    - 4: Three of a Kind
    - 3: Two Pair
    - 2: One Pair

- 1: High Card

2. A detailed ranking tuple containing card values in order of importance for breaking ties

The algorithm detects hand patterns by:

- Counting card values (pairs, three of a kind, etc.)
- Checking if all cards are the same suit (flush)
- Checking if card values form a consecutive sequence (straight)

3.4.2 Hand Combination Analysis

For a given set of community cards, the `analyze_all_possible_hands()` function:

1. Generates all possible 2-card combinations (hole cards)
2. For each combination, forms all possible 5-card hands using the community cards
3. Finds the best 5-card hand for each combination
4. Ranks all combinations based on their best hand
5. Assigns positions and calculates hand strength percentages

3.5 Hand Strength Calculation

Hand strength is calculated using the following process:

1. Sort all possible hands by rank
2. Assign positions to hands with the same rank (ties receive the same position)
3. Calculate raw strength for each hand using:

$$\text{strength} = \left(1 - \frac{\text{sum\_better\_hands}}{\text{total\_hands}}\right) \times 100 \tag{1}$$

4. Normalize strength values to a 0-100 scale

This provides a percentage representing how strong a hand is relative to all other possible hands given the current community cards.

4 Algorithmic Details

4.1 Hand Formation Algorithm

To find the best 5-card hand for each possible hole card combination:

```
def form_hands_from_board(hole_cards, board):
    all_cards = hole_cards + board
    return list(combinations(all_cards, 5))
```

This uses Python's `combinations` function from the `itertools` module to generate all possible 5-card combinations from the combined set of hole cards and community cards.

4.2 Hand Ordering for Display

Cards are ordered according to poker hand display conventions:

- Groups (pairs, three of a kind, etc.) are displayed first
- Higher value groups appear before lower value groups
- Kickers (single cards) are ordered by rank

This is implemented in the `order_hand_by_rank()` function.

4.3 Position Assignment Algorithm

Positions are assigned based on hand rank:

- Hands with the same rank receive the same position (ties)
- The ”T” suffix in position strings (e.g., ”1T”) indicates a tier/place
- Lower position numbers indicate stronger hands

5 Visualization Features

5.1 Hand Distribution Chart

The program visualizes the distribution of hand positions using matplotlib:

- Each bar represents the number of hole card combinations in a particular position
- The user's hand position is highlighted in green
- This visualization helps players understand where their hand ranks among all possibilities

5.2 Display Formats

The program offers two display formats for hand rankings:

- Detailed view (`display_hand_rankings()`): Shows all individual combinations with their exact cards
- Condensed view (`display_condensed_hand_rankings()`): Groups hands by position and displays them in standard poker notation:
  - ”AKs” - Ace-King suited
  - ”AKo” - Ace-King offsuit
  - ”AKos” - Ace-King both suited and offsuit variations

6 Program Flow

The main program flow follows these steps:

1. Create a deck of cards
2. Get player's hole cards (manual input or random)
3. Get flop cards (manual input or random)
4. Analyze all possible hands with the flop
5. Display hand rankings and player's hand statistics
6. Get turn card and analyze updated hand rankings
7. Get river card and analyze final hand rankings

At each stage (flop, turn, river), the program:

1. Displays the current board
2. Shows condensed rankings of all possible hole card combinations
3. Shows the player's hand statistics
4. Visualizes the position distribution

7 Mathematical Analysis

7.1 Position Factor Calculation

The position factor represents the percentage of hands that are worse than or tied with the current hand. It is calculated as:

$$\text{position\_factor} = 1 - \frac{\text{sum\_better\_hands}}{\text{total\_hands}} \tag{2}$$

Where:

- `sum_better_hands` is the number of hands in better positions
- `total_hands` is the total number of valid hole card combinations

7.2 Strength Normalization

To normalize strength values to a 0-100 scale:

$$\text{normalized\_strength} = \frac{\text{strength} - \text{min\_strength}}{\text{max\_strength} - \text{min\_strength}} \times 100 \tag{3}$$

This ensures that the best hand always has a strength of 100% and the worst hand has a strength of 0%.

8 Usage Examples

8.1 Manual Card Input

Users can manually input cards using formats like:

- ”A hearts” or ”A h” for Ace of Hearts
- ”10 spades” or ”10 s” for Ten of Spades
- ”K clubs” or ”K c” for King of Clubs

8.2 Reading the Condensed Hand Rankings

The condensed rankings display shows hand combinations in standard poker notation:

```
1T | AKs              | Pair          |    1 |    100.00
2T | AQs AQo          | Pair          |    1 |     90.50
3T | AJs KQs          | Pair          |    1 |     82.25
```

This indicates:

- First position (1T): AK suited makes a pair, using 1 hole card, with 100
- Second position (2T): AQ suited and offsuit make a pair, using 1 hole card, with 90.5
- Third position (3T): AJ suited and KQ suited both make a pair, using 1 hole card, with 82.25

9 Statistical Insights

9.1 Hole Card Usage

The program tracks how many hole cards are used in the best 5-card hand:

- 0: Neither hole card is used (playing the board)
- 1: One hole card is used with 4 community cards
- 2: Both hole cards are used with 3 community cards

This information helps players assess how much their hole cards contribute to their hand strength.

9.2 Tie Analysis

The program counts and displays tie statistics, showing how many hole card combinations result in equivalent hands. This information can help players assess the uniqueness of their hand.

10 Implementation Details

10.1 Dependencies

The program requires the following Python libraries:

- `random`: For shuffling cards and random selection
- `collections` (`Counter`, `defaultdict`): For frequency counting
- `colorama`: For colored terminal output
- `itertools.combinations`: For generating card combinations
- `pandas`: For data manipulation
- `matplotlib`: For visualization

10.2 Efficiency Considerations

Several optimizations are implemented:

- Skip combinations with one overlapping card from player's cards
- Use of set operations for card intersection checks
- Cache position and strength calculations

11 Condensed Example Output

Below is the commented output from a sample run of the Poker Hand Analysis Tool, showing how to interpret the results at each stage.

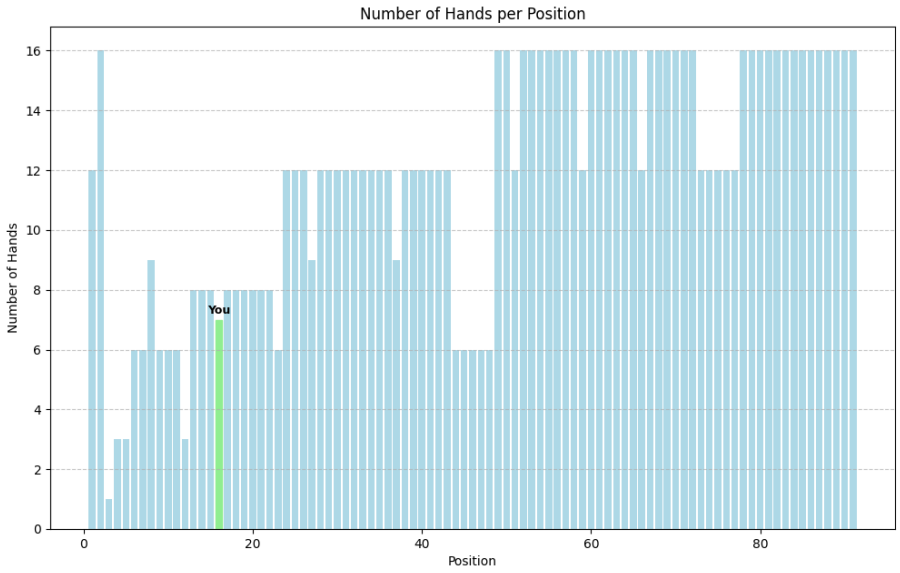
```
Poker Hand Analysis Tool
--------------------------------------------------
Do you want to enter your cards manually? (y/n): n

Your cards:
J ♣ 10 ♠
```

The program starts by asking if the user wants to input cards manually. In this case, random cards are chosen, resulting in the Jack of Clubs and Ten of Spades as the player's hole cards.

```
Do you want to enter the flop manually? (y/n): n

Flop:
10 ♢ 8 ♡ 7 ♢

Analyzing all possible combinations...
```

Random flop cards are generated: Ten of Diamonds, Eight of Hearts, and Seven of Diamonds. At this point, the player has a pair of tens (one in their hole cards, one on the board). The program then analyzes all possible hand combinations with this flop.

```
Condensed Hand Rankings (from best to worst):
--------------------------------------------------------------------------------
 Pos |         Hand         | Best Hand       | Used | Strength
--------------------------------------------------------------------------------
  1T | J9os                 | Straight        |    2 |   100.00
  2T | 96os                 | Straight        |    2 |    98.87
  3T | TTo                  | Three of a Kind |    2 |    97.37
  4T | 88o                  | Three of a Kind |    2 |    97.28
  5T | 77o                  | Three of a Kind |    2 |    97.00
  6T | T8os                 | Two Pair        |    2 |    96.72
  7T | T7os                 | Two Pair        |    2 |    96.15
  8T | 87os                 | Two Pair        |    2 |    95.59
  9T | AAo                  | One Pair        |    2 |    94.74
  ...
 16T | JTos                 | One Pair        |    2 |    90.53
  ...
 91T | 32os                 | High Card       |    2 |     0.00
```



The condensed rankings show all possible hand combinations organized by position (Pos). Key observations:

- Best hands are straights (J9 combinations) which complete the 7-8-9-10-J straight
- Three of a Kind hands (TT, 88, 77) are next strongest
- Our hand (JT) is at position 16T with a strength of 90.53% (One Pair)
- ”os” suffix indicates both offsuit and suited combinations are included
- ”T” suffix in position indicates a tier/position category

```
Tie Statistics:
Total ties: 90

Your Hand Statistics:
Hole Cards: J ♣ 10 ♠
Best Five Cards: 10 ♠ 10 ♢ J ♣ 8 ♡ 7 ♢
Hand Type: One Pair
Position: 16T
Strength: 90.53%
```

The player’s hand details after the flop:

- Best five-card hand uses both hole cards to make a pair of tens with J, 8, 7 kickers
- 90.53% strength indicates this hand is better than approximately 90% of all possible hands
- 90 total ties indicates how many hole card combinations would result in the same hand rank

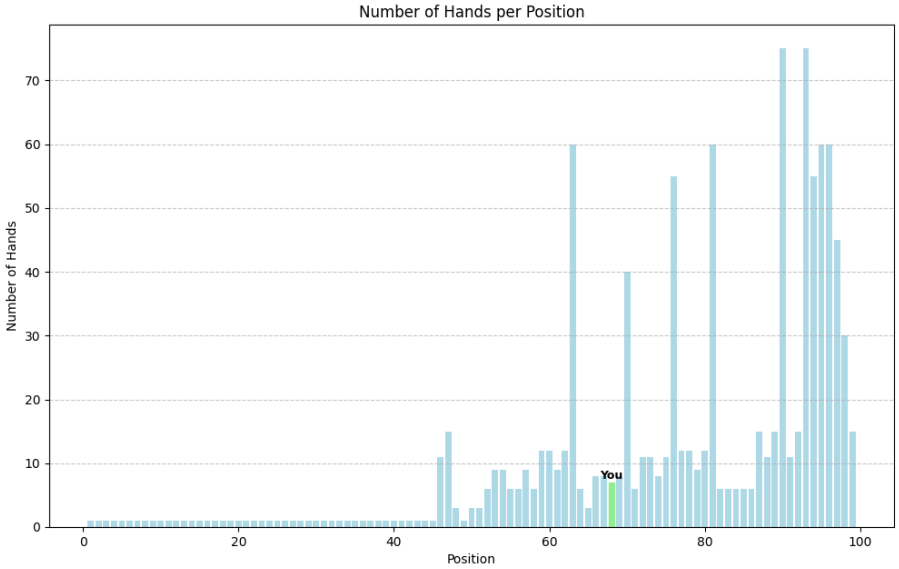
```
Do you want to enter the turn card manually? (y/n): n

Turn card:
K ♢

Analyzing all possible combinations after turn...
```

The turn card is the King of Diamonds. This is significant because:

- It’s the third diamond on the board, creating flush possibilities
- It’s a high card (King) that can pair with hole cards to make strong pairs

```
Condensed Hand Rankings (from best to worst):
--------------------------------------------------------------------------------
 Pos |         Hand         | Best Hand       | Used | Strength
--------------------------------------------------------------------------------
```

```
  1T | AQs                 | Flush          |    2 |   100.00
  2T | AJs                 | Flush          |    2 |    99.90
  3T | A9s                 | Flush          |    2 |    99.81
  ...
 46T | J9os                | Straight       |    2 |    95.60
  ...
 68T | JTos                | One Pair       |    2 |    74.34
  ...
 99T | 32os                | High Card      |    1 |     0.00
```



After the turn, the rankings have changed dramatically:

- Flushes now dominate the top positions (diamond suited hands)
- Straights have dropped to position 46T
- Our hand (JT) has fallen to position 68T with strength 74.34% (still a pair of tens)
- The prefix ”s” indicates suited hands (e.g., AQs means AQ of diamonds in this context)

```
Your Hand Statistics After Turn:
Hole Cards: J ♣ 10 ♠
Best Five Cards: 10 ♠ 10 ♢ K ♢ J ♣ 8 ♡
Hand Type: One Pair
Position: 68T
Strength: 74.34%
Cards Used from Hole Cards: 2
```

The player’s hand after the turn:

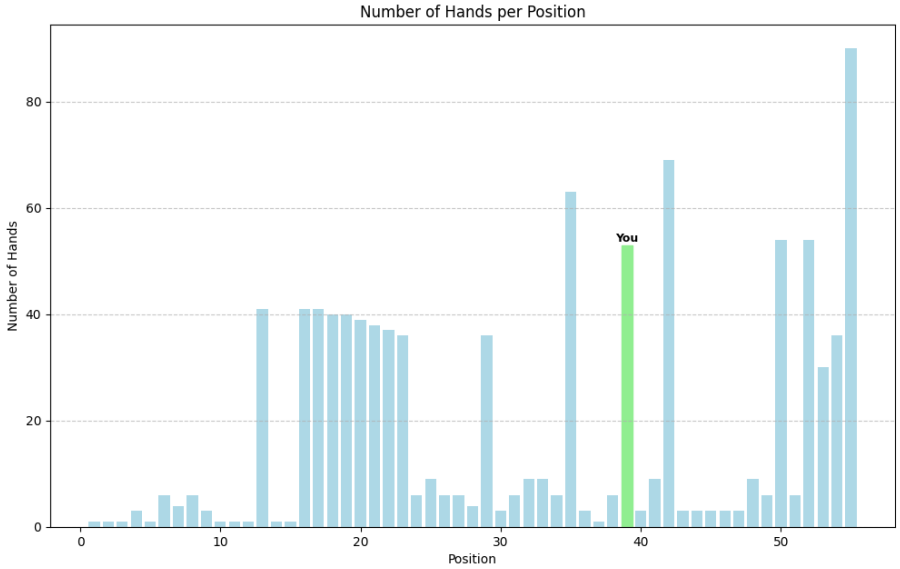
- Still a pair of tens, but now with stronger kickers (K, J, 8)
- Hand strength has dropped significantly from 90.53% to 74.34%
- Both hole cards are still being used in the best hand
- The hand is weaker relative to all possibilities due to flush potential

```
Do you want to enter the river card manually? (y/n): n

River card:
8 ♢

Analyzing all possible combinations after river...
```

The river card is the Eight of Diamonds, which:

- Adds a fourth diamond to the board, making flush possibilities stronger
- Creates a pair of eights on the board
- Opens up full house possibilities for players with eights in their hands

```
Condensed Hand Rankings (from best to worst):
--------------------------------------------------------------------------------
 Pos |         Hand         | Best Hand       | Used | Strength
--------------------------------------------------------------------------------
  1T | J9s                  | Straight Flush  |    2 |   100.00
  2T | 96s                  | Straight Flush  |    2 |    99.89
  3T | 88o                  | Four of a Kind  |    2 |    99.78
  4T | KKo                  | Full House      |    2 |    99.67
  5T | TTo                  | Full House      |    2 |    99.33
  ...
 39T | JTos QTos T2os T3os T4os T5os T6os T7os T9os | Two Pair        |    1 |    38.18
  ...
 55T | 32os 42os 43os 52os 53os 54os 62os 63os 64os 65os | One Pair        |    0 |     0.00
```



The final rankings show many powerful hands:

- Straight flushes (J9s, 96s) top the list
- Four of a kind (88o) and full houses are strong
- Our hand (JT) is now in a larger group at position 39T with strength 38.18%
- Multiple hole cards are now grouped together when they make the same hand
- The J♣ 10♠ now makes two pair (tens and eights) using just one hole card

```
Your Final Hand Statistics After River:
Hole Cards: J ♣ 10 ♠
Best Five Cards: 10 ♠ 10 ♢ 8 ♡ 8 ♢ K ♢
Hand Type: Two Pair
Position: 39T
Strength: 38.18%
Cards Used from Hole Cards: 1
```

The player's final hand:

- Two pair: tens and eights with a King kicker

- Only one hole card (10♠) is used in the best hand
- Position 39T is relatively weak at 38.18% strength
- The Jack of clubs is no longer part of the best five-card hand
- Hand strength dropped dramatically from flop (90.53%) to river (38.18%)

12 Output Analysis Summary

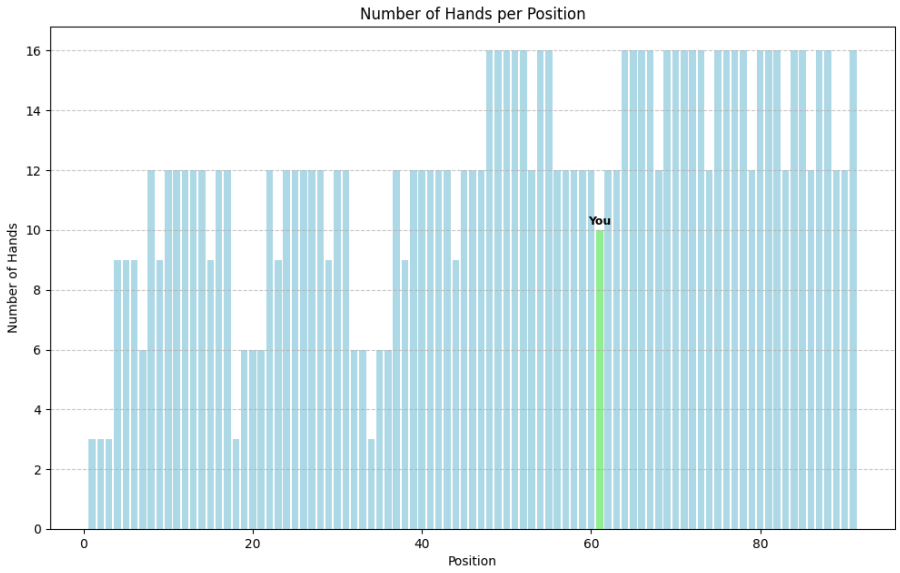
This example demonstrates how the condensed output function effectively displays hand ranking information through each stage of the game. Key insights from this analysis:

1. **Hand Strength Evolution**: The player's hand started strong (90.53%) but weakened considerably (38.18%) as community cards created better possibilities.
2. **Card Usage Changes**: Initially both hole cards were used, but by the river only one hole card remained in the best hand.
3. **Position Shifts**: The hand moved from position 16T to 68T and finally to 39T, showing the dynamic nature of poker.
4. **Board Texture Impact**: Diamond-heavy board created flush possibilities that dominated the rankings.
5. **Notation Efficiency**: The condensed notation effectively grouped similar hands (e.g., "T2os T3os T4os T5os T6os T7os T9os" all making the same two pair at the river).

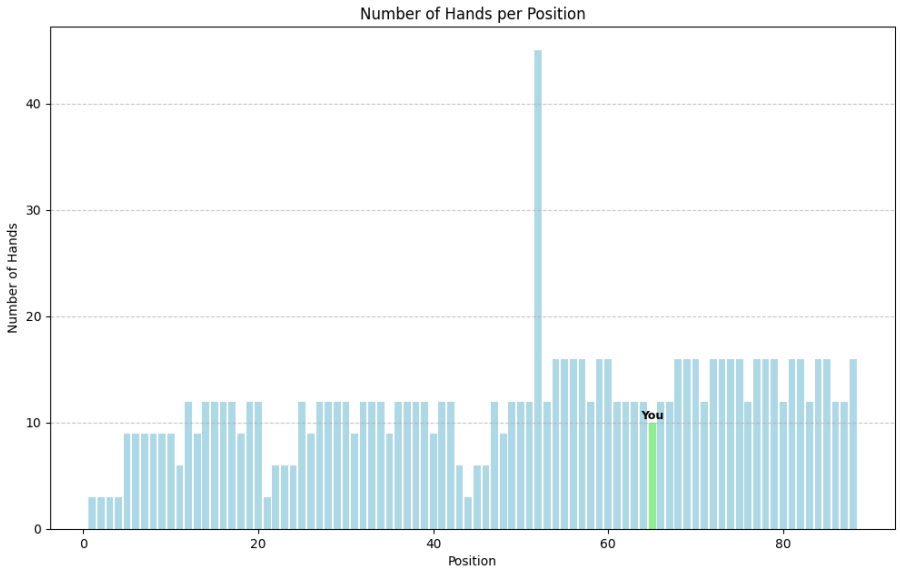
These insights demonstrate how the condensed function provides valuable strategic information that would be difficult to glean from a full listing of all 1,326 possible hole card combinations.

13 Detailed Example Output

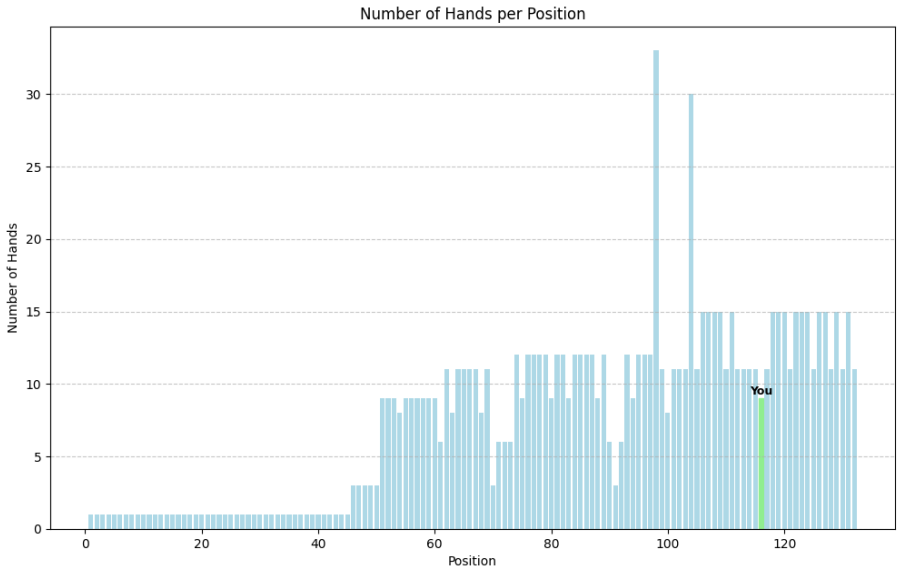
```
    Poker Hand Analysis Tool
-------------------------------------------------
Do you want to enter your cards manually? (y/n): n

Your cards:
Q ♢ 5 ♢

Do you want to enter the flop manually? (y/n): n

Flop:
K ♠ 8 ♡ 2 ♢

Analyzing all possible combinations...

All possible two-card combinations ranked (from best to worst):
-------------------------------------------------------------------------------------------------------------
 Pos | Hole Cards           | Best Hand       | Used | Strength | Best Five Cards
-------------------------------------------------------------------------------------------------------------
  1T | K ♡ K ♢ | Three of a Kind  |    2 |   100.00 | K ♡ K ♢ K ♠ 8 ♡ 2 ♢
  1T | K ♣ K ♡ | Three of a Kind  |    2 |   100.00 | K ♣ K ♡ K ♠ 8 ♡ 2 ♢
  1T | K ♣ K ♢ | Three of a Kind  |    2 |   100.00 | K ♣ K ♢ K ♠ 8 ♡ 2 ♢
  2T | 8 ♣ 8 ♢ | Three of a Kind  |    2 |    99.72 | 8 ♣ 8 ♢ 8 ♡ K ♠ 2 ♢
  2T | 8 ♠ 8 ♢ | Three of a Kind  |    2 |    99.72 | 8 ♠ 8 ♢ 8 ♡ K ♠ 2 ♢
  2T | 8 ♠ 8 ♣ | Three of a Kind  |    2 |    99.72 | 8 ♠ 8 ♣ 8 ♡ K ♠ 2 ♢
  3T | 2 ♣ 2 ♡ | Three of a Kind  |    2 |    99.44 | 2 ♣ 2 ♡ 2 ♢ K ♠ 8 ♡
  3T | 2 ♠ 2 ♡ | Three of a Kind  |    2 |    99.44 | 2 ♠ 2 ♡ 2 ♢ K ♠ 8 ♡
  3T | 2 ♠ 2 ♣ | Three of a Kind  |    2 |    99.44 | 2 ♠ 2 ♣ 2 ♢ K ♠ 8 ♡
...
 91T | 4 ♢ 3 ♠ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 4 ♢ 3 ♠ 2 ♢
 91T | 4 ♣ 3 ♣ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 4 ♣ 3 ♣ 2 ♢
 91T | 4 ♠ 3 ♣ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 4 ♠ 3 ♣ 2 ♢
 91T | 4 ♣ 3 ♠ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 4 ♣ 3 ♠ 2 ♢
 91T | 4 ♠ 3 ♠ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 4 ♠ 3 ♠ 2 ♢
```




```
Tie Statistics:
Total ties: 91

Your Hand Statistics:
Hole Cards: Q ♢ 5 ♢
Best Five Cards: K ♠ Q ♢ 8 ♡ 5 ♢ 2 ♢
Hand Type: High Card
Position: 61T
Strength: 41.09%

Do you want to enter the turn card manually? (y/n): n

Turn card:
7 ♡

Analyzing all possible combinations after turn...

All possible two-card combinations ranked (from best to worst):
-------------------------------------------------------------------------------------------------------------------
 Pos | Hole Cards           | Best Hand       | Used | Strength | Best Five Cards
-------------------------------------------------------------------------------------------------------------------
  1T | K ♡ K ♢ | Three of a Kind  |    2 |   100.00 | K ♡ K ♢ K ♠ 8 ♡ 7 ♡
  1T | K ♣ K ♡ | Three of a Kind  |    2 |   100.00 | K ♣ K ♡ K ♠ 8 ♡ 7 ♡
  1T | K ♣ K ♢ | Three of a Kind  |    2 |   100.00 | K ♣ K ♢ K ♠ 8 ♡ 7 ♡
  2T | 8 ♣ 8 ♢ | Three of a Kind  |    2 |    99.71 | 8 ♣ 8 ♢ 8 ♡ K ♠ 7 ♡
  2T | 8 ♠ 8 ♢ | Three of a Kind  |    2 |    99.71 | 8 ♠ 8 ♢ 8 ♡ K ♠ 7 ♡
  2T | 8 ♠ 8 ♣ | Three of a Kind  |    2 |    99.71 | 8 ♠ 8 ♣ 8 ♡ K ♠ 7 ♡
  3T | 7 ♣ 7 ♢ | Three of a Kind  |    2 |    99.41 | 7 ♣ 7 ♢ 7 ♡ K ♠ 8 ♡
...
 88T | 4 ♠ 3 ♢ | High Card        |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 4 ♠ 3 ♢
 88T | 4 ♢ 3 ♣ | High Card        |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 4 ♢ 3 ♣
 88T | 4 ♢ 3 ♠ | High Card        |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 4 ♢ 3 ♠
 88T | 4 ♣ 3 ♣ | High Card        |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 4 ♣ 3 ♣
 88T | 4 ♠ 3 ♣ | High Card        |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 4 ♠ 3 ♣
 88T | 4 ♣ 3 ♠ | High Card        |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 4 ♣ 3 ♠
 88T | 4 ♠ 3 ♠ | High Card        |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 4 ♠ 3 ♠
```




```
Your Hand Statistics After Turn:
Hole Cards: Q ♢ 5 ♢
Best Five Cards: K ♠ Q ♢ 8 ♡ 7 ♡ 5 ♢
Hand Type: High Card
Position: 65T
Strength: 32.36%
Cards Used from Hole Cards: 2

Do you want to enter the river card manually? (y/n): n

River card:
3 ♡

Analyzing all possible combinations after river...

All possible two-card combinations ranked (from best to worst):
-------------------------------------------------------------------------------------------------------------
 Pos | Hole Cards           | Best Hand       | Used | Strength | Best Five Cards
-------------------------------------------------------------------------------------------------------------
  1T | A ♡ K ♡ | Flush           |    2 |   100.00 | A ♡ K ♡ 8 ♡ 7 ♡ 3 ♡
  2T | A ♡ Q ♡ | Flush           |    2 |    99.90 | A ♡ Q ♡ 8 ♡ 7 ♡ 3 ♡
  3T | A ♡ J ♡ | Flush           |    2 |    99.80 | A ♡ J ♡ 8 ♡ 7 ♡ 3 ♡
  4T | A ♡ 10 ♡ | Flush          |    2 |    99.70 | A ♡ 10 ♡ 8 ♡ 7 ♡ 3 ♡
  5T | A ♡ 9 ♡ | Flush           |    2 |    99.60 | A ♡ 9 ♡ 8 ♡ 7 ♡ 3 ♡
  6T | A ♡ 6 ♡ | Flush           |    2 |    99.49 | A ♡ 8 ♡ 7 ♡ 6 ♡ 3 ♡
...
132T | 5 ♣ 4 ♢ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 5 ♣ 4 ♢
132T | 5 ♠ 4 ♢ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 5 ♠ 4 ♢
132T | 5 ♣ 4 ♣ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 5 ♣ 4 ♣
132T | 5 ♠ 4 ♣ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 5 ♠ 4 ♣
132T | 5 ♣ 4 ♠ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 5 ♣ 4 ♠
132T | 5 ♠ 4 ♠ | High Card       |    2 |     0.00 | K ♠ 8 ♡ 7 ♡ 5 ♠ 4 ♠
```




```
Your Final Hand Statistics After River:
Hole Cards: Q ♢ 5 ♢
Best Five Cards: K ♠ Q ♢ 8 ♡ 7 ♡ 5 ♢
Hand Type: High Card
Position: 116T
Strength: 21.83%
Cards Used from Hole Cards: 2
```

14 Conclusion

The Poker Hand Analysis Tool provides a comprehensive analysis of poker hand strength throughout a game. By analyzing all possible hole card combinations and visualizing hand distributions, it gives players a clear understanding of their hand's relative strength at each stage of the game.

This tool can be valuable for:

- Poker strategy development
- Hand analysis and study
- Training poker decision-making skills
- Understanding the impact of community cards on hand strength

The mathematical models and algorithms used ensure accurate ranking and strength calculations, making this a reliable tool for poker analysis.