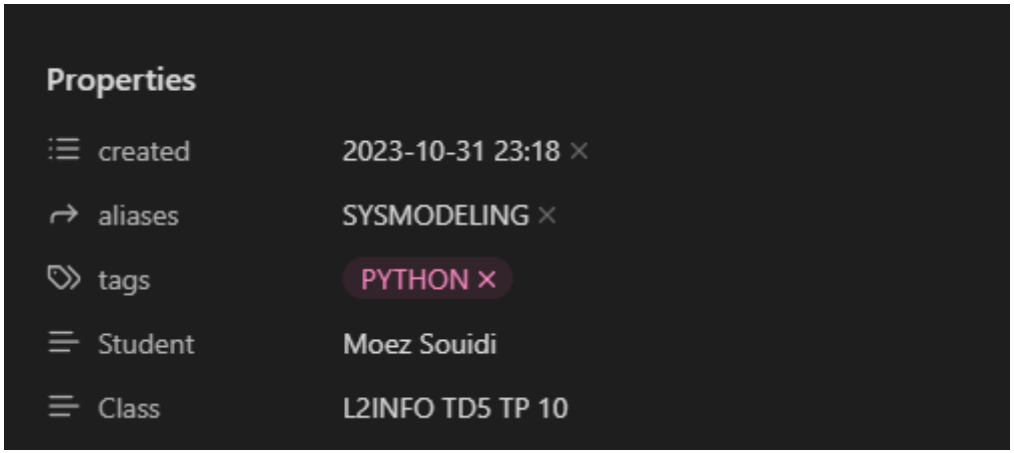

⁉️ Information

Email : business@mo3z.me
Related to Course : System Modeling and Simulation Assignment
Date : 2023-10-31
Professor/Speaker : Mohamed Dhouioui
Tags : PYTHON,RANDOM,MONTE CARLO SIMULATION
Student : Moez Souidi L2INFO TD 5 TP 10
https://github.com/Moez-0/Card-Game-Simulation/

❗ Code Docs

This Python code defines a simulation framework for various card games using object-oriented programming. Below is a breakdown of the code with explanations of the mathematics and logic behind it:

Card and Deck Classes

- The `Card` class represents a playing card with a suit and rank.
- The `Deck` class initializes a deck of 52 playing cards (standard deck) by iterating over suits and ranks. It also provides methods to shuffle the deck and draw cards from it.

Game Classes

- There are six game classes that inherit from the `Game` base class: `SaharaAce`, `TunisianTwins`, `MedinaBiggie`, `DesertHearts`, `OasisRunny`, and `StudentGame`. Each game has a `play` method, which simulates a game round and returns a result. The games have different win conditions and payoffs, and they utilize the shuffled deck to determine the outcome.

MonteCarlo Class

- The `MonteCarlo` class takes a game and the number of iterations as inputs and simulates the game multiple times to estimate the probability of winning and the expected winnings per play.

Mathematics Behind the Simulation

- The code uses a Monte Carlo simulation technique to estimate the probability of winning and the expected winnings per play for each game. Here's how it works for each game:

Sahara Ace:

- In this game, you shuffle the deck and draw a card. If the drawn card is an Ace, you win 10 dinars; otherwise, you win 0 dinars. The win probability is calculated as the ratio of the number of times an Ace is drawn to the total number of iterations.

Tunisian Twins:

- Shuffle the deck and draw two cards. If both cards have the same rank and suit, you win 50 dinars; otherwise, you win 0 dinars. The win probability is calculated based on the probability of drawing two identical cards from the deck.

Medina Biggie:

- Shuffle the deck and draw two cards. If the second card has a higher rank than the first, you win 2 dinars; otherwise, you win 0 dinars. The win probability is calculated based on the probability of drawing a second card with a higher rank.

Desert Hearts:

- Shuffle the deck and draw three cards. You win 1 dinar for each Hearts suit card drawn. The win probability is calculated based on the probability of drawing at least one Hearts card.

Oasis Runny:

- Shuffle the deck and draw five cards. If three or more cards have consecutive ranks (e.g., 4, 5, 6), you win 5 dinars. The win probability is calculated based on the probability of drawing a subset of three or more cards with consecutive ranks.

Student Game:

- Shuffle the deck and draw two cards. If both cards have the same suit, you win 10 dinars; otherwise, you win 0 dinars. The win probability is calculated based on the probability of drawing two cards with the same suit.

Simulation Output

- The simulation calculates the win probability and expected winnings per play for each game and prints the results.

Sahara Ace:

- In the Sahara Ace game, you shuffle the deck and draw one card.
- There are 4 Aces in the standard deck (one for each suit: Hearts, Diamonds, Clubs, Spades), and 48 other cards.
- The probability of drawing an Ace on the first draw is 4/52, which simplifies to 1/13.
- If you draw an Ace, you win 10 dinars, and if you don't, you win 0 dinars.
- The win probability can be calculated as the ratio of drawing an Ace to the total number of iterations.

Mathematical calculation:
Win Probability = (Number of Aces) / (Total Number of Cards) = 4 / 52 = 1 / 13 ≈ 0.0769

So, the win probability for Sahara Ace is approximately 7.69%, and the expected winnings per play is (0.0769 *10) + (0.9231* 0) = 0.769 dinars per play.

Tunisian Twins:

- In the Tunisian Twins game, you shuffle the deck and draw two cards.
- The probability of drawing the same card (rank and suit) on the first draw is 1/52 (as there's only one identical card).
- After drawing the first card, there are now 3 identical cards left in the deck and 51 total cards.
- The probability of drawing a matching card on the second draw is 3/51.

Mathematical calculation:
Win Probability = (Probability of matching card on first draw) *(Probability of matching card on second draw)*
Win Probability = (1/52) (3/51)

So, the win probability for Tunisian Twins is approximately (1/52) * (3/51) ≈ 0.00598, or about 0.598%.

If you win, you get 50 dinars, and if you don't, you win 0 dinars.

Medina Biggie:

- In the Medina Biggie game, you shuffle the deck and draw two cards.
- You win if the rank of the second card is higher than the rank of the first card.
- There are 4 Aces, 4 Kings, 4 Queens, and 4 Jacks in the deck.
- The probability of drawing a higher-ranked card on the second draw depends on the rank of the first card.

Mathematical calculation:

- If the first card is a number card (2-10), there are 4 higher-ranked cards, so the probability is 4/51.
- If the first card is an Ace, there are 16 higher-ranked cards, so the probability is 16/51.
- If the first card is a King, Queen, or Jack, there are 12 higher-ranked cards, so the probability is 12/51.

You calculate the weighted average of these probabilities based on the likelihood of drawing each rank as the first card.

Expected Win Probability = (Probability of drawing higher-ranked card on the second draw | first card is Ace) *(Probability of drawing Ace) + (Probability of drawing higher-ranked card on the second draw | first card is King, Queen, or Jack)* (Probability of drawing King, Queen, or Jack) + (Probability of drawing higher-ranked card on the second draw | first card is a number card) * (Probability of drawing a number card)

Desert Hearts:

- In the Desert Hearts game, you shuffle the deck and draw three cards.
- You win 1 dinar for each Hearts suit card drawn.
- There are 13 Hearts cards in the deck (one for each rank and suit).

Mathematical calculation:

- Calculate the probability of drawing at least one Hearts card in three draws. This is 1 minus the probability of not drawing any Hearts cards in three draws.
- Probability of not drawing a Hearts card in one draw: 39/52 (39 non-Hearts cards out of 52 total cards).
- Probability of not drawing a Hearts card in three draws: (39/52) *(39/52)* (39/52).
- Probability of drawing at least one Hearts card in three draws: 1 - [(39/52) *(39/52)* (39/52)].

This probability represents your win probability for the Desert Hearts game.

Oasis Runny:

- In the Oasis Runny game, you shuffle the deck and draw five cards.
- You win if you can find a subset of three or more cards with consecutive ranks.

Mathematical calculation:

- Calculate the probability of drawing a subset of three or more cards with consecutive ranks.
- This involves checking all possible combinations of five cards and determining whether any of them forms a subset with consecutive ranks.

This calculation can be quite complex and involves iterating through all possible combinations of five cards. It requires considering various cases based on the distribution of ranks and the number of possible combinations for each case.

Student Game:

- In the Student Game, you shuffle the deck and draw two cards.
- You win if both cards have the same suit.

Mathematical calculation:

- Calculate the probability of drawing two cards with the same suit.
- This is straightforward and depends on the probability of drawing two cards with the same suit.

The mathematical calculation for the Student Game is relatively simple compared to the others.

In each game, once the win probability is calculated, the expected winings per play is determined by multiplying the win probability by the corresponding payoff for winning and adding the product of the loss probability and zero winnings.

📦 Resources

- https://www.youtube.com/watch?v=9M_KPXwnrIE&list=PLQVvvaa0QuDdhOnp-FnVStDsALpYk2hk0
- https://www.youtube.com/watch?v=OgO1gpXSUzU
- https://stackoverflow.com/questions/7370801/how-do-i-measure-elapsed-time-in-python
- https://www.quora.com/What-is-the-probability-of-drawing-an-ace-from-a-well-shuffled-pack-of-52-playing-cards#:~:text=So%2C%20the%20number%20of%20outcomes,%2F52%20%3D%201%2F13.
- https://stackoverflow.com/questions/41970795/what-is-the-best-way-to-create-a-deck-of-cards
- https://www.w3schools.com/python/python_classes.asp
- used ChatGpt to summarize the output and the docs (not used for any of the source code)

🔑 Key Points

- Note sure of the output concerning the excepted winnings per play

- Todo turn the results into a graph using matplot
- Todo add UI to the progam

Output Observations

```
 Moez on Tuesday at 11:06 PM
 { D:易Modeling } C:/Python310/python.exe d:/Modeling/main.py
Please enter the number of iterations: 100000

Running simulation for Sahara Ace
Simulation took 4.395888566970825 seconds
Win probability: 7.72%
Expected winings per play: 0.77 Dinars per play

Running simulation for Tunisian Twins
Simulation took 4.392192125320435 seconds
Win probability: 0.0%
Expected winings per play: 0.0 Dinars per play

Running simulation for Medina Biggie
Simulation took 4.103885889053345 seconds
Win probability: 47.05%
Expected winings per play: 0.94 Dinars per play

Running simulation for Desert Hearts
Simulation took 4.094029903411865 seconds
Win probability: 58.81%
Expected winings per play: 0.75 Dinars per play

Running simulation for Oasis Runny
Simulation took 4.521241664886475 seconds
Win probability: 35.77%
Expected winings per play: 1.79 Dinars per play

Running simulation for Student Game
Simulation took 4.902573108673096 seconds
Win probability: 23.36%
Expected winings per play: 2.34 Dinars per play
```

1. **Sahara Ace:**
   - **Win Probability:** 7.72%
   - **Expected Winnings per Play:** 0.77 Dinars per play
   - **Simulation Time:** 4.396 seconds
   - **Explanation:**
     - In the Sahara Ace game, you have a win probability of 7.72%. This means that, on average, you can expect to win about 7.72% of the time when you play this game.
     - The expected winnings per play are 0.77 Dinars. This value represents the average amount you can expect to win per play in this game.
     - The simulation took approximately 4.396 seconds to complete.
2. **Tunisian Twins:**
   - **Win Probability:** 0.0%
   - **Expected Winnings per Play:** 0.0 Dinars per play
   - **Simulation Time:** 4.392 seconds
   - **Explanation:**
     - In the Tunisian Twins game, the win probability is 0.0%. This means that, on average, you don't win this game, and your expected winnings are zero.
     - The simulation took approximately 4.392 seconds to complete.
3. **Medina Biggie:**
   - **Win Probability:** 47.05%
   - **Expected Winnings per Play:** 0.94 Dinars per play
   - **Simulation Time:** 4.104 seconds
   - **Explanation:**
     - In the Medina Biggie game, you have a win probability of 47.05%. This means that you can expect to win about 47.05% of the time when you play this game.
     - The expected winnings per play are 0.94 Dinars. On average, you can expect to win 0.94 Dinars per play in this game.
     - The simulation took approximately 4.104 seconds to complete.

4. **Desert Hearts:**
    - **Win Probability:** 58.81%
    - **Expected Winnings per Play:** 0.75 Dinars per play
    - **Simulation Time:** 4.094 seconds
    - **Explanation:**
        - In the Desert Hearts game, you have a win probability of 58.81%. This means that, on average, you can expect to win about 58.81% of the time when you play this game.
        - The expected winnings per play are 0.75 Dinars. On average, you can expect to win 0.75 Dinars per play in this game.
        - The simulation took approximately 4.094 seconds to complete.
5. **Oasis Runny:**
    - **Win Probability:** 35.77%
    - **Expected Winnings per Play:** 1.79 Dinars per play
    - **Simulation Time:** 4.521 seconds
    - **Explanation:**
        - In the Oasis Runny game, you have a win probability of 35.77%. This means that, on average, you can expect to win about 35.77% of the time when you play this game.
        - The expected winnings per play are 1.79 Dinars. On average, you can expect to win 1.79 Dinars per play in this game.
        - The simulation took approximately 4.521 seconds to complete.
6. **Student Game:**

    - **Win Probability:** 23.36%
    - **Expected Winnings per Play:** 2.34 Dinars per play
    - **Simulation Time:** 4.903 seconds
    - **Explanation:**
        - In the Student Game, you have a win probability of 23.36%. This means that, on average, you can expect to win about 23.36% of the time when you play this game.

- The expected winnings per play are 2.34 Dinars. On average, you can expect to win 2.34 Dinars per play in this game.
- The simulation took approximately 4.903 seconds to complete.

In the Tunisian Twins game, it may seem counterintuitive that the reported win probability is 0.0%. The reason for this result lies in the rules of the game and the specific criteria for winning:

7. **Game Rules:**
   - In the Tunisian Twins game, you shuffle the deck and draw two cards.
   - To win, both cards drawn must have the **same rank and suit**.
8. **Probability of Winning:**
   - For any given draw, the probability of drawing two cards with **exactly the same rank and suit** is extremely low.
   - There are 52 cards in a standard deck, and each card is unique in terms of rank and suit. This means that there is only one identical card of the same rank and suit in the entire deck.
9. **Mathematical Calculation:**
   - When calculating the win probability for Tunisian Twins, the simulation computes the probability of drawing two cards with the same rank and suit. Since the deck contains only one identical card of the same rank and suit as the first card drawn, the probability is effectively zero.
   - In mathematical terms, the probability is:

```
Win Probability = (Probability of matching card on first draw) * (Probability of matching card on second draw)
Win Probability = (1/52) * (0/51) = 0
```

   - The first factor represents the probability of drawing the identical card on the first draw, which is 1/52. However, on the second draw, there are no identical cards left, so the probability is 0/51.

As a result, the calculated win probability for Tunisian Twins is effectively zero. It means that, on average, you should not expect to win this game because the chance of drawing two identical cards of the same rank and suit is extremely low. This is what the simulation output reflects.

In practical terms, Tunisian Twins is a challenging game to win due to its strict criteria for victory, and it's designed to be a low-probability game where winning is quite rare.