Artificial Intelligence Methods

Assignment 1

Sindre Lian Thronæs sindrelt@stud.ntnu.no

Course: TDT4171
Term: Spring 2023
Handed in: 23.01.23

1 Exercise 1 - Card Deck 1

2 Exercise 2 - Slot Machine 2

3 Exercise 3 - Birthdays 3

NTNU
Norwegian University of Science and Technology

Department of Computer Science
Norwegian University of Science and Technology

1 Exercise 1 - Card Deck

a) When dealing five-card poker hands at random from a standard deck of 52 cards there will be no repetition of cards as there are 13 different ranks of each suit, thus making each card unique in the deck. However the value of two cards may be equal, but that is not relevant for this task. A five-card poker hand is also a unordered sample as the physical order in which one may hold the cards in their hands does not matter for the game. An unordered selection without repetition yields the formula for "n choose r":

$$\binom{n}{r} = \binom{52}{5} = \frac{52!}{5!(52-5)!} = 2598960$$

Thus there are 2598960 five-card hands.

b) The probability of a event is the number of favorable outcomes divided by the total outcomes. The probability of each atomic event is therefore:

$$\frac{1}{2598960} \approx 3.85 \times 10^{-7}$$

c) A royal straight flush is a five-card hand with cards of sequential rank starting from "10" to "Ace" and of the same suit. There are only 4 possible ways of achieving this so therefore the probability of being dealt a royal straight flush is really low:

$$\frac{4}{2598960} \approx 1.54 \times 10^{-6}$$

Four of a kind can be achieved in a number of different ways. Still, there are only 13 different ranks in total so there can not be more than 13 distinct four of a kind. The fifth card however, can be one of 4*12 different cards. Thus the number of ways four of a kind can appear in a five-card hand is:

$$13 \times 12 \times 4 = 624$$

The probability of being dealt a four of a kind is therefore:

$$\frac{624}{2598960} \approx 2.4 \times 10^{-3}$$

2 Exercise 2 - Slot Machine

a) [1]The expected "payback" percentage for the machine can be calculated from the formula for an average, since this is a good estimator for an expected value from a uniform distribution. One may also calculate this by multiplying the probability of getting the different combinations with their payback respectively and adding them all together to find the expected return. Worth noticing that this is also the average return when betting one coin.

$$\overline{x} = \frac{1}{n}\sum_{i=0}^{n} x_i$$

Thus the expected coin return can be calculated as the following:

$$ExpectedReturn = \frac{1}{64}(20 + 15 + 5 + 3 + 2 + 1) = \frac{46}{64} = 0.71875$$

This yields an expected "payback" percentage of 71.8% for the machine.

b) The total number of possible slot combinations are $4^3 = 64$. The event Win is when the slot machine returns one of the winning combinations/states showed in the assignment:

$$\begin{aligned} Win = 3xBAR \vee 3xBELL \vee 3xLEMON \vee 3xCHERRY \\ \vee 2xCHERRY \vee 1xCHERRY \end{aligned} \tag{1}$$

Since the three wheels are independent of each other the probability of the set of events is the sum of the individual probabilities of each individual event:

$$\begin{aligned} P(Win) = P(3xBAR) + P(3xBELL) + P(3xLEMON) \\ +P(3xCHERRY) + P(2xCHERRY) + P(1xCHERRY) \end{aligned} \tag{2}$$

There are 4 ways of getting "3 of a kind", 3 ways of getting $2xCHERRY$, and there are 9 ways of getting $1xCHERRY$. Thus there are $4+3+9 = 16$ distinct combinations that yields a winning result. The probability that playing the slot machine once will result in a win can then be calculated in the following way:

$$P(Win) = \frac{16}{64} = \frac{1}{4} = 0.25$$

[1]For the entirety of task 2 I assume the ordering of the slot machine matters from left to right as shown in the assingment sheet. Thus the combination $?-?-CHERRY$ won't be a winning combination.

Thus there is a 25% chance of winning when playing each time.
c) From the simulation in Python I have estimated the mean number of plays you can expect to make until you go broke if you start with 10 coins to be around 212 plays . The median though is 21 plays. These results has been made from $1 * 10^5$ simulations. [2]Underneath follows the output from the terminal.

```
● sindrethronaes@Sindres-MacBook-Pro-2 01 % python simulationV2.py
  The average number of plays for this slot machine one can expect to make before going broke is 212.2027 plays.
  The median of plays is 21.0 plays.
```

3 Exercise 3 - Birthdays

Part 1

a) The function that takes N and computes the probability via simulation is called birthday_Simulation() in assignment.py. I also added another argument to specify how many simulations one would like to perform.

b) The proportion of N where the event happens with the least 50% chance is from 23 to 50 people. The smallest N where the probability of the event occurring is at least 50% is 23 people. These results comes from 10 000 simulations. Underneath follows the output from the terminal.

```
● sindrethronaes@Sindres-MacBook-Pro-2 01 % python simulationV2.py
  The probability is 0.12 for a occurrence of same birth date among 10 people.
  The probability is 0.1433 for a occurrence of same birth date among 11 people.
  The probability is 0.1664 for a occurrence of same birth date among 12 people.
  The probability is 0.1974 for a occurrence of same birth date among 13 people.
  The probability is 0.2239 for a occurrence of same birth date among 14 people.
  The probability is 0.2449 for a occurrence of same birth date among 15 people.
  The probability is 0.2889 for a occurrence of same birth date among 16 people.
  The probability is 0.3164 for a occurrence of same birth date among 17 people.
  The probability is 0.3492 for a occurrence of same birth date among 18 people.
  The probability is 0.3847 for a occurrence of same birth date among 19 people.
  The probability is 0.4154 for a occurrence of same birth date among 20 people.
  The probability is 0.4429 for a occurrence of same birth date among 21 people.
  The probability is 0.4763 for a occurrence of same birth date among 22 people.
  The probability is 0.5133 for a occurrence of same birth date among 23 people.
  The probability is 0.5316 for a occurrence of same birth date among 24 people.
  The probability is 0.5654 for a occurrence of same birth date among 25 people.
  The probability is 0.5926 for a occurrence of same birth date among 26 people.
  The probability is 0.6281 for a occurrence of same birth date among 27 people.
  The probability is 0.6548 for a occurrence of same birth date among 28 people.
  The probability is 0.6877 for a occurrence of same birth date among 29 people.
  The probability is 0.7039 for a occurrence of same birth date among 30 people.
  The probability is 0.7259 for a occurrence of same birth date among 31 people.
  The probability is 0.7584 for a occurrence of same birth date among 32 people.
  The probability is 0.7862 for a occurrence of same birth date among 33 people.
  The probability is 0.7927 for a occurrence of same birth date among 34 people.
  The probability is 0.8116 for a occurrence of same birth date among 35 people.
  The probability is 0.8337 for a occurrence of same birth date among 36 people.
  The probability is 0.8464 for a occurrence of same birth date among 37 people.
  The probability is 0.8626 for a occurrence of same birth date among 38 people.
  The probability is 0.8782 for a occurrence of same birth date among 39 people.
  The probability is 0.8911 for a occurrence of same birth date among 40 people.
  The probability is 0.9076 for a occurrence of same birth date among 41 people.
  The probability is 0.9129 for a occurrence of same birth date among 42 people.
  The probability is 0.9256 for a occurrence of same birth date among 43 people.
  The probability is 0.9317 for a occurrence of same birth date among 44 people.
  The probability is 0.9413 for a occurrence of same birth date among 45 people.
  The probability is 0.9479 for a occurrence of same birth date among 46 people.
  The probability is 0.9545 for a occurrence of same birth date among 47 people.
  The probability is 0.9575 for a occurrence of same birth date among 48 people.
  The probability is 0.9668 for a occurrence of same birth date among 49 people.
  The probability is 0.9739 for a occurrence of same birth date among 50 people.
```

[2]The source code (assignment1.py) will be delivered separately along with this pdf-report.

Part 2

a) Peter should expect to form a group of around 2370 people before every day of the year, is the birthday of at least one person from the group. Underneath follows the output from the terminal.

```
● sindrethronaes@Sindres-MacBook-Pro-2 01 % python assignment1.py
  One must expect to include 2363.6208 people in a group before each day in a year is a birthday for the group.
● sindrethronaes@Sindres-MacBook-Pro-2 01 % python assignment1.py
  One must expect to include 2371.5229 people in a group before each day in a year is a birthday for the group.
● sindrethronaes@Sindres-MacBook-Pro-2 01 % python assignment1.py
  One must expect to include 2367.0753 people in a group before each day in a year is a birthday for the group.
```