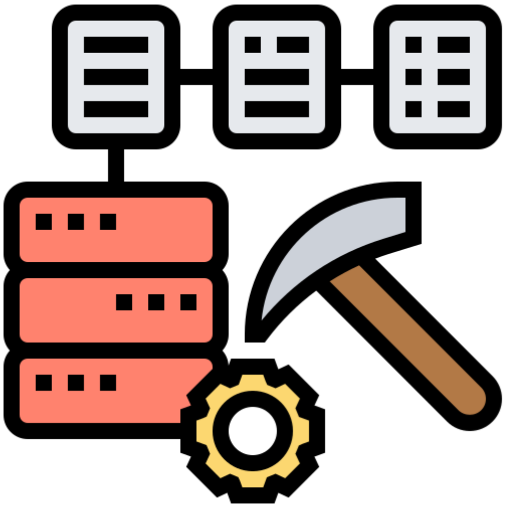

Data Mining

Homework 1

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Problem 1

1. I choose the probability space such that each element in Ω corresponds to a unique ordering of the cards in the deck.
   Mathematically, $\Omega = \{\sigma_1, \sigma_2, \sigma_3, \ldots, \sigma_{52!}\}$, where each σ_i is a distinct permutation.
   Since each permutation in Ω is equally likely when we shuffle a standard deck of cards, we have a uniform probability distribution.
   The probability measure P assigns equal probabilities to all permutations in Ω. Therefore, for any event $A \subseteq \Omega$, we have:

   $$P(A) = \frac{|A|}{52!}$$

   Specifically, for each individual permutation σ_i in Ω:

   $$P(\sigma_i) = \frac{1}{52!}$$

2. Probability of the each event is:

   (a) **Finding the probability that the first two cards include at least one ace**
   We can use the complement rule:

   $$\text{Probability (at least one ace in the first two cards)} =$$

   $$1 - \text{ Probability (no aces in the first two cards)}$$

   Now, let's calculate the probability of not getting any aces in the first two cards. There are 52 cards in the deck initially, and 48 of them are not aces. When we pick the first card, there are 48 non-ace cards out of 52 possibilities. After picking the first card, there are now 51 cards left in the deck, with 47 of them being non-ace cards. Therefore, the probability of not getting an ace on the second card, given that the first card was not an ace, is:

   $$\frac{48}{52} \cdot \frac{47}{51}$$

So, the probability that the first two cards contain at least one ace is:

$$1 - \left(\frac{48}{52} \cdot \frac{47}{51}\right) \approx 0.1494$$

(b) **Finding the probability that the first five cards include at least one ace**

Same as item (a) we can use the complement rule:

$$\text{Probability (at least one ace in the first five cards)} =$$

$$1 - \text{ Probability (no aces in the first five cards)}$$

Same as previous item, the probability of not getting an ace on the first 5 cards, is:

$$\frac{48}{52} \cdot \frac{47}{51} \cdot \frac{46}{50} \cdot \frac{45}{49} \cdot \frac{44}{28}$$

So, the probability that the first five cards include at least one ace:

$$1 - \left(\frac{48}{52} \cdot \frac{47}{51} \cdot \frac{46}{50} \cdot \frac{45}{49} \cdot \frac{44}{28}\right) \approx 0.3147$$

(c) **The first two cards are a pair of the same rank**

To find the probability that the first two cards drawn from a standard deck are a pair of the same rank, you can approach it as follows:

- There are 52 cards in a standard deck.
- For the first card, there are no restrictions, so there are 52 possibilities.
- For the second card, you want it to be of the same rank as the first card, which means there are 3 cards of the same rank left in the deck (since there are 4 cards of each rank in a standard deck, and you've already drawn one).

So, the probability of drawing a pair of the same rank for the first two cards is:

$$\text{Probability} = \frac{52/52 \cdot 3/51}{1} = \frac{1}{17}$$

So, the probability of drawing the first two cards as a pair of the same rank is $1/17 \approx 0.0588$.

(d) **The first five cards are all diamonds.**

There are 13 diamonds in a standard deck.

The probability of drawing a diamond on the first draw is $\frac{13}{52}$ because there are 13 diamonds out of 52 cards.

Similarly, for the second, third, fourth, and fifth draws, the probabilities are as follows:

Second draw: $\frac{12}{51}$

Third draw: $\frac{11}{50}$

Fourth draw: $\frac{10}{49}$

Fifth draw: $\frac{9}{48}$

Because these are independent events, we can multiply these probabilities together:

$$\frac{13}{52} \cdot \frac{12}{51} \cdot \frac{11}{50} \cdot \frac{10}{49} \approx 0.00018184$$

So, the probability of drawing the first five cards as diamonds is approximately 0.00018184, or about 0.0182%.

(e) **The first five cards form a full house**

There are $\binom{4}{3} = 4$ different ways to choose 3 cards of the same type and $\binom{4}{2} = 6$ different ways to choose 2 cards of the same type. To get a full house, you need to first pick the type of the 3 of a kind, which is $\binom{13}{1} =$ 13 different choices, and choose the type of the pair, which is $\binom{12}{1} = 12$ different choices. The order does not count, so there are $\binom{13}{1} \cdot \binom{4}{3} \cdot \binom{12}{1} \cdot \binom{4}{2}$ ways to have a full house.

$$\binom{13}{1} \cdot \binom{4}{3} \cdot \binom{12}{1} \cdot \binom{4}{2} = 3744$$

Note that there are $\binom{52}{5} = 2,598,960$ different combinations for the first 5 cards, so the probability of being dealt a full house is:

$$\frac{3744}{2,598,960} \approx 0.14\%$$

Problem 2

1. For calculating the probability that the baby born at midnight was a boy I design the following probability space: let's define E_1 and E_2 as following:

   b: Number of boys before midnight (In our case 4)

   g: Number of girls before midnight

   E_1: boy is born at midnight

   E_2: girl is born at midnight

   Let say that initially there were n girls.

   B: boy picked up by nurse

   G: girl picked up by nurse

2. We have to calculate $P(E_1|B)$:

$$P(E_1|B) = \frac{P(E_1 \cap B)}{P(B)}$$

   Assumption: I assumed, when a child is born, the probability of that child being either a boy or a girl is 50%

   The chance of picking a boy, which we'll call P(B), is calculated by adding together the probability of picking a boy such that the boy was born at midnight and the probability of picking a boy such that the girl was born at midnight.

$$P(B) = \frac{1}{2} \cdot P(B|E_1) + \frac{1}{2} \cdot P(B|E_2)$$

$$P(B) = \frac{1}{2} \cdot \frac{b+1}{b+1+g} + \frac{1}{2} \cdot \frac{b}{b+1+g} = \frac{1}{2} \cdot \frac{2b+1}{b+1+g}$$

   As $P(E_1 \cap B) = P(B \cap E_1)$, and $P(B \cap E_1) = P(B|E_1) \cdot P(E_1) \ldots$

$$P(E_1|B) = \frac{P(B|E_1) \cdot P(E_1)}{P(B)}$$

   So,

$$P(E_1|B) = \frac{\frac{1}{2} \cdot \frac{b+1}{b+1+g}}{\frac{1}{2} \cdot \frac{2b+1}{b+1+g}} = \frac{b+1}{2b+1} = \frac{5}{9} \approx 0.56$$

Problem 3

Let's define the following probability space for this problem:

n: Number of times your roll three dices
E_{11} : Sum is 11
E_{16} : Sum is 16
E_{11}^C : Sum is not 11
E_{16}^C : Sum is not 16

Let's simulate some numbers of rolling times and calculate the possible outcomes to gain an insight:

$$n = 1 \rightarrow \begin{cases} E_{11}^1 & P(E_{11}) = \frac{18}{216} \\ E_{16}^1 & P(E_{16}) = \frac{6}{216} \\ (E_{11}^1 \textit{ and } E_{16}^1)^C & P(E_{11}^C \cup E_{16}^C) = \frac{195}{216} \end{cases}$$

$$n = 2 \xrightarrow[\text{in n = 1}]{\text{Sum was not 11 not 16}} \begin{cases} E_{11}^2 & P(E_{11}) = \frac{195}{216} \cdot \frac{18}{216} \\ E_{16}^2 & P(E_{16}) = \frac{195}{216} \cdot \frac{6}{216} \\ (E_{11}^2 \textit{ and } E_{16}^2)^C & P(E_{11}^C \cup E_{16}^C) = \frac{195}{216} \cdot \frac{195}{216} \end{cases}$$

$$n = 3 \xrightarrow[\text{not n = 1 nor in n = 2}]{\text{Sum was not 11 not 16}} \begin{cases} E_{11}^3 & P(E_{11}) = \frac{195}{216} \cdot \frac{195}{216} \cdot \frac{18}{216} \\ E_{16}^3 & P(E_{16}) = \frac{195}{216} \cdot \frac{195}{216} \cdot \frac{6}{216} \\ (E_{11}^3 \textit{ and } E_{16}^3)^C & P(E_{11}^C \cup E_{16}^C) = \frac{195}{216} \cdot \frac{195}{216} \cdot \frac{195}{216} \end{cases}$$

So, we found a trend!
The probability that you stop because you see a sum of 16 in the n^{th} time is:

$$P(E_{16})^n = P(E_{11}^C \cup E_{16}^C)^{n-1} \cdot P(E_{16})$$

Which will be:

$$P(E_{16})^n = (\frac{195}{216})^{n-1} \cdot \frac{6}{216}$$

Problem 4

Problem 5

To find the probability of seeing a bicycle in a given time interval, we can assume that the probability of seeing a bicycle remains constant over time.

We already know the probability of seeing a bicycle in 45 minutes as P(45), which is 97$\%$. We want to find the probability of seeing a bicycle in a 15-minute interval, written as P(15).

Since the probability remains constant, we can assume that the ratio of probabilities is the same as the ratio of time intervals:

$$\frac{P(15)}{P(45)} = \frac{15}{45}$$

To find P(15), we can rearrange the equation:

$$P(15) = \frac{15}{45} \times P(45)$$

Substituting the given value of P(45) as 97$\%$ or 0.97:

$$P(15) = \frac{15}{45} \times 0.97$$

Calculating this expression:

$$P(15) = 0.32$$

Therefore, the probability of seeing a bicycle in a 15-minute interval is 32$\%$.

Problem 6

Problem 7

For this problem a console program based on two libraries:

1. *requests* Python library → DirectAPIClient.py
2. *meteomatics.api* library → HighLevelAPIClient.py

Retrieving Data Using DirectAPIClient Class

The `DirectAPIClient` class retrieves weather data from the Meteomatics API through the following steps:

1. It formats the time range for the query using the provided start date, end date, and interval.
2. The API URL is constructed by combining the base URL, time range, selected parameters, coordinates (latitude and longitude), and specifying the output format as JSON.
3. An HTTP GET request is sent to the constructed API URL, including your Meteomatics API username and password for authentication.
4. The response from the API is captured and checked for its status code.
5. In the case of a successful response (status code 200), the function parses the JSON response and extracts the weather data.
6. The weather data is processed to obtain time series for each selected parameter.
7. A Plotly figure is created, with traces (lines) added for each parameter to visualize trends over time.
8. The function includes error handling for errors based on the given HTTP status codes and provides informative error messages.
9. Also exception handling is implemented to catch any unexpected exceptions during the process.
10. The Plotly figure is displayed, allowing users to analyze and visualize the weather data.

How to Use The Program

Run Python Main.py

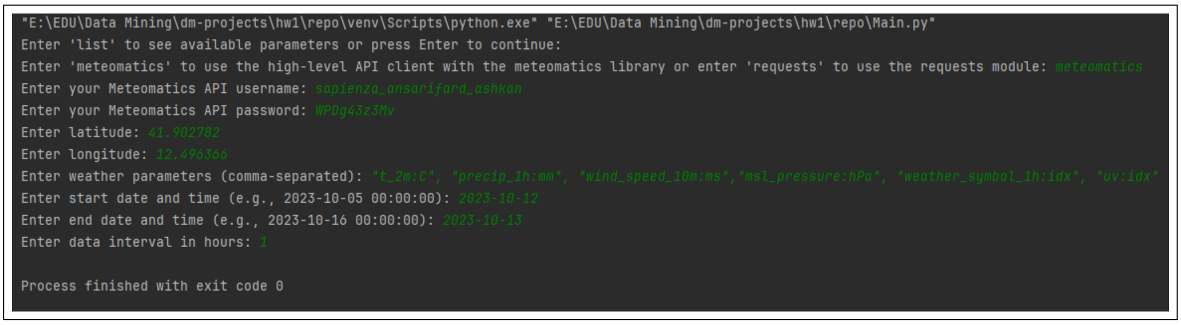
Follow the prompts to select parameters, input dates and time intervals, and choose either the high-level or direct API client.

The program will then query the Meteomatics API, retrieve weather data, and display it as a Plotly graph.

You can visualize and analyze the trends of the selected weather parameters over a any time period that you want.

Example

In this example, Precipitation, Wind speed, Pressure, Weather Symbol and UV trend over 24 hours is plotted.



```
"E:\EDU\Data Mining\dm-projects\hw1\repo\venv\Scripts\python.exe" "E:\EDU\Data Mining\dm-projects\hw1\repo\Main.py"
Enter 'list' to see available parameters or press Enter to continue:
Enter 'meteomatics' to use the high-level API client with the meteomatics library or enter 'requests' to use the requests module: meteomatics
Enter your Meteomatics API username: sapienza_ansarifard_ashkan
Enter your Meteomatics API password: WPDg43z3Mv
Enter latitude: 41.902782
Enter longitude: 12.496366
Enter weather parameters (comma-separated): "t_2m:C", "precip_1h:mm", "wind_speed_10m:ms","msl_pressure:hPa", "weather_symbol_1h:idx", "uv:idx"
Enter start date and time (e.g., 2023-10-05 00:00:00): 2023-10-12
Enter end date and time (e.g., 2023-10-16 00:00:00): 2023-10-13
Enter data interval in hours: 1

Process finished with exit code 0
```

Figure 1: Console Output of the Example

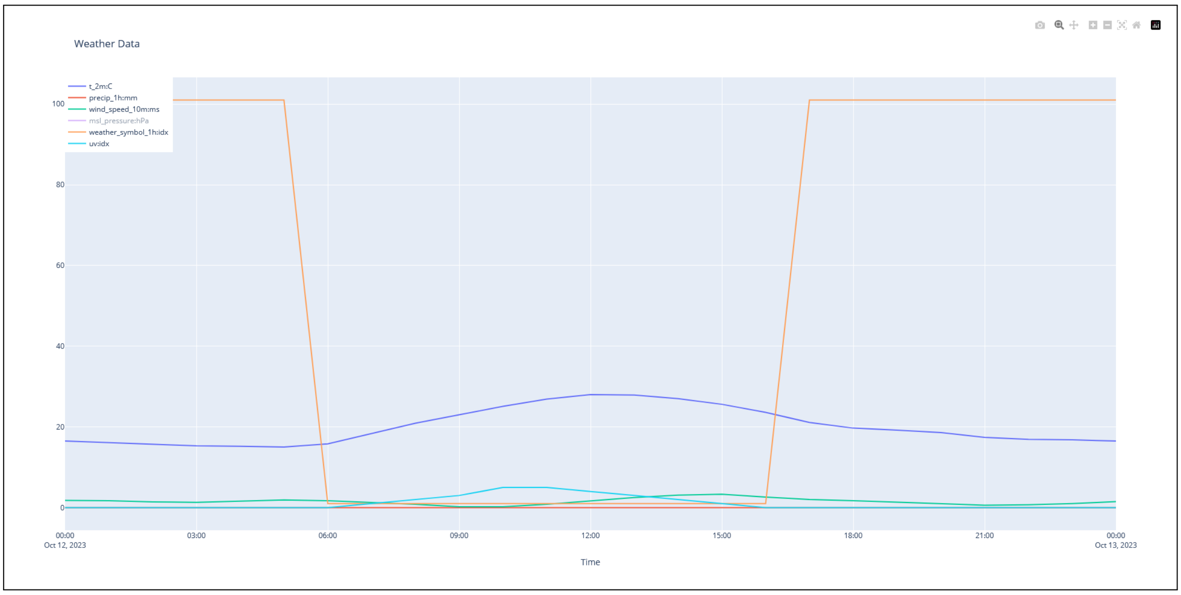


Figure 2: Plot of Precipitation, Wind speed, Pressure, Weather Symbol and UV trend over 24 hours