Use natural language to create charts and graphs

Estimated time needed: **30** minutes

Overview

Imagine you are a data analyst or a data scientist of a marketing team at an e-commerce company. The company needs to understand customer purchasing behaviors over the last year to tailor their upcoming holiday campaigns. Traditionally, this would involve complex SQL queries, data wrangling in Python, and perhaps building visual dashboards to interpret the results including analyzing spreadsheets, creating charts, and maybe even some statistical analysis—tasks that require considerable time and expertise.

With the integration of Langchain and LLMs, you can simply ask, "Show me a visualization of monthly sales trends by product category," or "Generate a heatmap of customer activity by region." The system would use the `create_pandas_dataframe_agent` to process the CSV data, and then dynamically generate visualizations such as line graphs, bar charts, or heatmaps in response to these queries. This not only speeds up the data analysis process but also allows team members who may not be tech-savvy to engage directly with the data and make informed decisions quickly. This approach fosters a more collaborative environment and ensures that strategic decisions are backed by real-time data insights, visually represented for easy comprehension.

In this lab, you will learn how to seamlessly integrate data visualization into your conversational data analysis using Langchain and LLMs. Starting with CSV file data, you will use the `create_pandas_dataframe_agent` to build an interactive agent that not only understands and responds to your queries but also translates data responses into visual formats. You will explore how to dynamically generate charts, graphs, and heatmaps directly in response to natural language questions. This capability will enable you to visualize trends, compare figures, and spot patterns immediately, making your data analysis workflow both efficient and visually engaging. By the end of this project, you will have the skills to create a data conversational agent that acts as both analyst and visualizer, bringing data to life through dialogue.

In this lab we are going to use Llama 3 LLM hosted on the IBM watsonx.ai platform.

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Objectives

After completing the project, you should be able to:

- **Use Langchain with large language models**: Understand and apply the Langchain framework in conjunction with LLMs to interact with and analyze data stored in CSV files through natural language processing.
- **Create conversational data agents**: Build a conversational agent that can understand and respond to natural language queries about data, enabling users to ask questions directly and receive immediate answers.
- **Implement data visualization through dialogue**: Integrate data visualization tools within your conversational agent, allowing you to request and generate visual data representations such as graphs, charts, and heatmaps dynamically based on your queries.
- **Enhance decision-making process**: Develop the capability to derive actionable insights from data via interactive dialogues and visual outputs, thereby improving the decision-making process and making data analysis accessible to non-technical stakeholders.

Setup

This project is based on Jupyter Notebook. If you're not familiar with it, here's a quick guide on how to run code within it:

A Jupyter Notebook consists of cells. To execute a code cell, click on the cell that you want to run and click the 'Run' button, as shown in the picture.

For this lab, we will be using the following libraries:

- `ibm-watson-ai` for using LLMs from IBM's watsonx.ai.
- `LangChain`, `langchain-ibm`, `langchain-experimental` for using its agent function to interact with data.
- `matplotlib` for additional plotting tools.
- `seaborn` for visualizing the data.

Installing required libraries

The following required libraries are **not** preinstalled in the Skills Network Labs environment. **You must run the following cell** to install them:

Note: We are pinning the version here to specify the version. It's recommended that you do this as well. Even if the library is updated in the future, the installed library could still support this lab work.

This might take approximately 1-2 minutes.

As we use `%%capture` to capture the installation, you won't see the output process. But after the installation completes, you will see a number beside the cell.

```
%%capture
!pip install ibm-watsonx-ai=="0.2.6"
!pip install langchain=="0.1.16"
!pip install langchain-ibm=="0.1.4"
!pip install langchain-experimental=="0.0.57"
!pip install matplotlib=="3.8.4"
!pip install seaborn=="0.13.2"
```

After you installat the libraries, restart your kernel. You can do that by clicking the **Restart the kernel** icon.

Importing required libraries

We recommend you import all required libraries in one place (here):

```
# We use this section to suppress warnings generated by your code:
def warn(*args, **kwargs):
    pass
import warnings
warnings.warn = warn
warnings.filterwarnings('ignore')

from ibm_watsonx_ai.foundation_models import Model
from ibm_watsonx_ai.metanames import GenTextParamsMetaNames as
GenParams
from
ibm_watson_machine_learning.foundation_models.extensions.langchain
import WatsonxLLM

from langchain_experimental.agents.agent_toolkits import
create_pandas_dataframe_agent

import matplotlib.pyplot as plt
import pandas as pd
```

Data set

In this lab, you will work on the Student Alcohol Consumption data set `student-mat.csv` by UCI Machine Learning as an example. For more information, see Kaggle. It is based on data collected from two secondary schools in Portugal. The students included in the survey were in mathematics and Portuguese courses.

The data set we are using is for the mathematics course. The number of mathematics students involved in the collection was 395. The data collected in locations such as Gabriel Pereira and Mousinho da Silveira includes several pertinence values. Examples of such data are records of demographic information, grades, and alcohol consumption.

Field	Description
school	GP/MS for the student's school
sex	M/F for gender
age	15-22 for the student's age
address	U/R for urban or rural, respectively
famsize	LE3/GT3 for less than or greater than three family members
Pstatus	T/A for living together or apart from parents, respectively
Medu	0 (none) / 1 (primary-4th grade) / 2 (5th - 9th grade) / 3 (secondary) / 4 (higher) for mother's education
Fedu	0 (none) / 1 (primary-4th grade) / 2 (5th - 9th grade) / 3 (secondary) / 4 (higher) for father's education
Mjob	'teacher,' 'health' care related, civil 'services,' 'at_home' or 'other' for the student's mother's job
Fjob	'teacher,' 'health' care related, civil 'services,' 'at_home' or 'other' for the student's father's job
reason	reason to choose this school (nominal: close to 'home', school 'reputation', 'course' preference or 'other')
guardian	mother/father/other as the student's guardian
traveltime	1 (<15mins) / 2 (15 - 30 mins) / 3 (30 mins - 1 hr) / 4 (>1hr) for a time from home to school
studytime	1 (<2hrs) / 2 (2 - 5hrs) / 3 (5 - 10hrs) / 4 (>10hrs) for weekly study time
failures	1-3/4 for the number of class failures (if more than three, then record 4)
schoolsup	yes/no for extra educational support
famsup	yes/no for family educational support
paid	yes/no for extra paid classes for Math or Portuguese
activities	yes/no for extra-curricular activities
nursery	yes/no for whether attended nursery school
higher	yes/no for the desire to continue studies
internet	yes/no for internet access at home
romantic	yes/no for relationship status
famrel	1-5 scale on quality of family relationships
freetime	1-5 scale on how much free time after school
goout	1-5 scale on how much student goes out with friends
Dalc	1-5 scale on how much alcohol consumed on weekdays
Walc	1-5 scale on how much alcohol consumed on the weekend
health	1-5 scale on health condition
absences	0-93 number of absences from school
G1	0-20 for the first-period grade

Field	Description
G2	0-20 for the second-period grade
G3	0-20 for the final grade

Load the data set

Execute the code in the following cell to load your dataset. This code reads the CSV file into a pandas DataFrame, making the data accessible for processing in Python.

```
df = pd.read_csv(
    "https://cf-courses-data.s3.us.cloud-object-
storage.appdomain.cloud/ZNoKMJ9rssJn-QbJ49k0zA/student-mat.csv"
)
```

Let's examine the first five rows of the dataset to get a glimpse of the data structure and its contents.

```
df.head(5)

  school sex  age address famsize Pstatus  Medu  Fedu     Mjob
Fjob  ...  \
0     GP   F   18       U     GT3       A     4     4  at_home
teacher  ...
1     GP   F   17       U     GT3       T     1     1  at_home
other  ...
2     GP   F   15       U     LE3       T     1     1  at_home
other  ...
3     GP   F   15       U     GT3       T     4     2   health
services  ...
4     GP   F   16       U     GT3       T     3     3    other
other  ...

  famrel freetime  goout  Dalc  Walc health absences  G1  G2  G3
0       4         3      4     1     1      3         6   5   6   6
1       5         3      3     1     1      3         4   5   5   6
2       4         3      2     2     3      3        10   7   8  10
3       3         2      2     1     1      5         2  15  14  15
4       4         3      2     1     2      5         4   6  10  10

[5 rows x 33 columns]
```

We can also review the detailed information for each column in the dataset, focusing on the presence of null values and the specific data types of each column.

```
df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 395 entries, 0 to 394
Data columns (total 33 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   school      395 non-null    object
 1   sex         395 non-null    object
 2   age         395 non-null    int64
 3   address     395 non-null    object
 4   famsize     395 non-null    object
 5   Pstatus     395 non-null    object
 6   Medu        395 non-null    int64
 7   Fedu        395 non-null    int64
 8   Mjob        395 non-null    object
 9   Fjob        395 non-null    object
 10  reason      395 non-null    object
 11  guardian    395 non-null    object
 12  traveltime  395 non-null    int64
 13  studytime   395 non-null    int64
 14  failures    395 non-null    int64
 15  schoolsup   395 non-null    object
 16  famsup      395 non-null    object
 17  paid        395 non-null    object
 18  activities  395 non-null    object
 19  nursery     395 non-null    object
 20  higher      395 non-null    object
 21  internet    395 non-null    object
 22  romantic    395 non-null    object
 23  famrel      395 non-null    int64
 24  freetime    395 non-null    int64
 25  goout       395 non-null    int64
 26  Dalc        395 non-null    int64
 27  Walc        395 non-null    int64
 28  health      395 non-null    int64
 29  absences    395 non-null    int64
 30  G1          395 non-null    int64
 31  G2          395 non-null    int64
 32  G3          395 non-null    int64
dtypes: int64(16), object(17)
memory usage: 102.0+ KB
```

Load LLM

Execute the code in the cell below to load the llama-3-70b LLM model from watsonx.ai.

Additionally, we will configure the LLM to interact with data by integrating it with Langchain's `create_pandas_dataframe_agent`.

```
# Create a dictionary to store credential information
credentials = {
    "url"    : "https://us-south.ml.cloud.ibm.com"
}
```

```
# Indicate the model we would like to initialize. In this case, Llama 3 70B.
model_id    = 'meta-llama/llama-3-70b-instruct'

# Initialize some watsonx.ai model parameters
params = {
        GenParams.MAX_NEW_TOKENS: 256, # The maximum number of tokens that the model can generate in a single run.
        GenParams.TEMPERATURE: 0,   # A parameter that controls the randomness of the token generation. A lower value makes the generation more deterministic, while a higher value introduces more randomness.
    }
project_id  = "skills-network" # <--- NOTE: specify "skills-network" as your project_id
space_id    = None
verify      = False

# Launch a watsonx.ai model
model = Model(
    model_id=model_id,
    credentials=credentials,
    params=params,
    project_id=project_id,
    space_id=space_id,
    verify=verify
)

# Integrate the watsonx.ai model with the langchain framework
llm = WatsonxLLM(model = model)

agent = create_pandas_dataframe_agent(
    llm,
    df,
    verbose=False,
    return_intermediate_steps=True  # set return_intermediate_steps=True so that model could return code that it comes up with to generate the chart
)
```

Interact with your data

Let's start with a simple interaction.

Ask LLM how many rows of data are in the CSV file.

```
response = agent.invoke("how many rows of data are in this file?")

response['output']
```

```
'395'
```

From the output above, the model reports that there are 395 rows of data in the file.

Let's verify this count using Python code to ensure accuracy.

```
len(df)

395
```

The row count matches and is correct!

Curious about the code the LLM generated and used to create this result?

Run the code in the cell below to reveal the underlying commands.

```
response['intermediate_steps'][0][0].tool_input.replace('; ', '\n')

'len(df)'
```

Surprisingly, the LLM uses the same code as we do.

Also, we could let LLM return some data that we are looking for based on the CSV file.

```
response = agent.invoke("Give me all the data where student's age is
over 18 years old.")

print(response)

{'input': "Give me all the data where student's age is over 18 years
old.", 'output': 'The final answer is the dataframe with the students
who are over 18 years old.', 'intermediate_steps':
[(AgentAction(tool='python_repl_ast', tool_input="df[df['age'] > 18]",
log="Thought: I need to filter the dataframe to get the rows where the
age is greater than 18.\nAction: python_repl_ast\nAction Input:
df[df['age'] > 18]"),     school sex  age address famsize Pstatus
Medu  Fedu      Mjob      Fjob  \
127      GP   F   19       U     GT3       T     0     1   at_home
other
153      GP   M   19       U     GT3       T     3     2  services
at_home
210      GP   F   19       U     GT3       T     3     3     other
other
247      GP   M   22       U     GT3       T     3     1  services
services
257      GP   M   19       U     LE3       A     4     3  services
at_home
270      GP   F   19       U     GT3       T     3     3     other
services
296      GP   F   19       U     GT3       T     4     4    health
```

```
other
304     GP   M   19        U     GT3        T     3     3     other
other
306     GP   M   20        U     GT3        A     3     2  services
other
307     GP   M   19        U     GT3        T     4     4   teacher
services
308     GP   M   19        R     GT3        T     3     3     other
services
309     GP   F   19        U     LE3        T     1     1   at_home
other
310     GP   F   19        U     LE3        T     1     2  services
services
311     GP   F   19        U     GT3        T     2     1   at_home
other
312     GP   M   19        U     GT3        T     1     2     other
services
313     GP   F   19        U     LE3        T     3     2  services
other
314     GP   F   19        U     GT3        T     1     1   at_home
health
315     GP   F   19        R     GT3        T     2     3     other
other
336     GP   F   19        R     GT3        A     3     1  services
at_home
340     GP   F   19        U     GT3        T     2     1  services
services
350     MS   M   19        R     GT3        T     1     1     other
services
353     MS   M   19        R     GT3        T     1     1     other
other
370     MS   F   19        U     LE3        T     3     2  services
services
376     MS   F   20        U     GT3        T     4     2    health
other
383     MS   M   19        R     GT3        T     1     1     other
services
387     MS   F   19        R     GT3        T     2     3  services
other
390     MS   M   20        U     LE3        A     2     2  services
services
392     MS   M   21        R     GT3        T     1     1     other
other
394     MS   M   19        U     LE3        T     1     1     other
at_home

         reason guardian  traveltime  studytime  failures schoolsup
famsup  \
127      course    other           1          2         3        no
```

```
yes
153        home   mother           1          1         3        no
yes
210  reputation    other           1          4         0        no
yes
247       other   mother           1          1         3        no
no
257  reputation   mother           1          2         0        no
yes
270        home    other           1          2         2        no
yes
296  reputation    other           2          2         0        no
yes
304        home    other           1          2         1        no
yes
306      course    other           1          1         0        no
no
307  reputation    other           2          1         1        no
yes
308  reputation   father           1          2         1        no
no
309  reputation    other           1          2         1       yes
yes
310        home    other           1          2         1        no
no
311       other    other           3          2         0        no
yes
312      course    other           1          2         1        no
no
313  reputation    other           2          2         1        no
yes
314        home    other           1          3         2        no
no
315  reputation    other           1          3         1        no
no
336        home    other           1          3         1        no
no
340        home    other           1          3         1        no
no
350        home    other           3          2         3        no
no
353        home    other           3          1         1        no
yes
370        home    other           2          2         2        no
no
376      course    other           2          3         2        no
yes
383       other   mother           2          1         1        no
no
```

```
387      course   mother           1          3         1        no
no
390      course    other           1          2         2        no
yes
392      course    other           1          1         3        no
no
394      course   father           1          1         0        no
no

    paid activities nursery higher internet romantic  famrel  freetime
goout  \
127   no         no      no     no       no       no       3         4
2
153   no         no     yes     no      yes      yes       4         5
4
210  yes        yes     yes    yes      yes       no       4         3
3
247   no         no      no     no      yes      yes       5         4
5
257   no         no     yes    yes      yes       no       4         3
1
270  yes        yes     yes    yes      yes       no       4         3
5
296  yes        yes     yes    yes      yes       no       2         3
4
304   no        yes     yes    yes      yes      yes       4         4
4
306   no        yes     yes    yes       no       no       5         5
3
307  yes         no     yes    yes      yes      yes       4         3
4
308   no        yes     yes    yes       no      yes       4         5
3
309   no        yes      no    yes      yes       no       4         4
3
310   no        yes      no    yes       no      yes       4         2
4
311   no         no     yes     no      yes      yes       3         4
1
312   no         no      no    yes      yes       no       4         5
2
313  yes         no      no    yes      yes      yes       4         2
2
314   no         no      no    yes      yes      yes       4         1
2
315   no         no     yes    yes      yes      yes       4         1
2
336  yes         no     yes    yes       no       no       5         4
3
```

```
340  yes        yes     yes    yes      yes      yes       4         3
4
350   no         no     yes    yes      yes       no       5         4
4
353   no         no     yes    yes      yes       no       4         4
4
370   no        yes     yes    yes       no      yes       3         2
2
376  yes         no      no    yes      yes      yes       5         4
3
383   no         no     yes    yes       no       no       4         3
2
387   no        yes      no    yes      yes       no       5         4
2
390  yes         no     yes    yes       no       no       5         5
4
392   no         no      no    yes       no       no       5         5
3
394   no         no     yes    yes      yes       no       3         2
3

     Dalc  Walc  health  absences  G1  G2  G3
127     1     1       5         2   7   8   9
153     1     1       4         0   5   0   0
210     1     2       3        10   8   8   8
247     5     5       1        16   6   8   8
257     1     1       1        12  11  11  11
270     3     3       5        15   9   9   9
296     2     3       2         0  10   9   0
304     1     1       3        20  15  14  13
306     1     1       5         0  17  18  18
307     1     1       4        38   8   9   8
308     1     2       5         0  15  12  12
309     1     3       3        18  12  10  10
310     2     2       3         0   9   9   0
311     1     1       2        20  14  12  13
312     2     2       4         3  13  11  11
313     1     2       1        22  13  10  11
314     1     1       3        14  15  13  13
315     1     1       3        40  13  11  11
336     1     2       5        12  14  13  13
340     1     3       3         4  11  12  11
350     3     3       2         8   8   7   8
353     3     3       5         4   8   8   8
370     1     1       3         4   7   7   9
376     1     1       3         4  15  14  15
383     1     3       5         0   6   5   0
387     1     2       5         0   7   5   0
390     4     5       4        11   9   9   9
```

```
392      3     3       3         3  10    8   7
394      3     3       5         5   8    9   9   )]}
```

Let's get the code LLM used for charting this plot.

```
response['intermediate_steps'][0][0].tool_input.replace('; ', '\n')
```

```
"df[df['age'] > 18]"
```

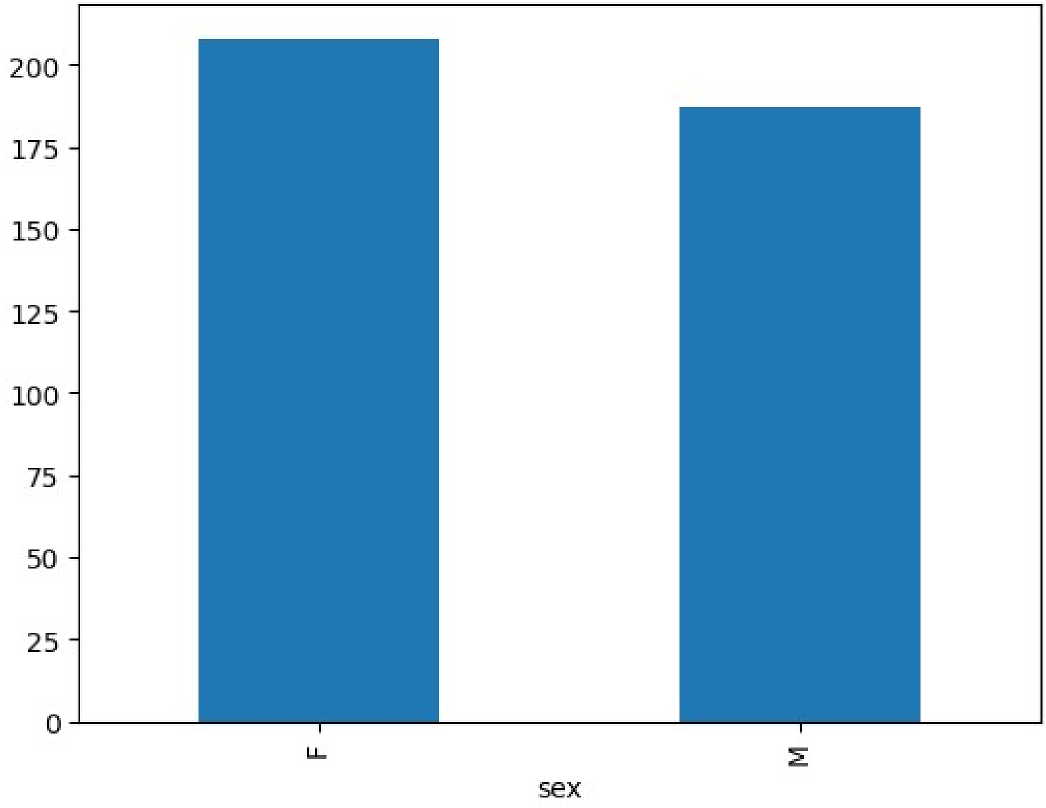
Plot your data with natural language

Task 1

Generating a first visual on the data set to know the total number of male and female students in the data set.

We just tell the agent that "Plot the gender count with bars."

```
response = agent.invoke("Plot the gender count with bars.")
```



Let's see what code the LLM generated for ploting this chart.

```
print(response['intermediate_steps'][0][0].tool_input.replace('; ', '\n'))
```

```
df['sex'].value_counts().plot(kind='bar')
```

Task 2

Generating a pie chart for displaying the average value of weekend alcohol for each gender in the data set.

We will use the prompt "Generate a pie chart to display average value of Walc for each gender."

You may notice that the model generates two charts. The charts actually indicate the progressive improvement of the agent's code as it searches for the best way to answer to our prompt. It presents an improvement in the response to our query.

```
response = agent.invoke("Generate a pie chart to display average value of Walc for each Gender.")
```

Let's get the code LLM used for charting this plot.

```
print(response['intermediate_steps'][0][0].tool_input.replace('; ', '\n'))
```

Task 3

We can explore the impact of free time on grades based on the data.

```
response = agent.invoke("Create box plots to analyze the relationship between 'freetime' (amount of free time) and 'G3' (final grade) across different levels of free time.")
```

Execute the code below to retrieve the Python script the LLM used for plotting.

```
print(response['intermediate_steps'][0][0].tool_input.replace('; ', '\n'))
```

Task 4

We can explore the effect of alcohol consumption on academic performance.

```
response = agent.invoke("Generate scatter plots to examine the correlation between 'Dalc' (daily alcohol consumption) and 'G3', and between 'Walc' (weekend alcohol consumption) and 'G3'.")
```

Execute the code below to retrieve the Python script the LLM used for plotting.

```
print(response['intermediate_steps'][0][0].tool_input.replace('; ', '\n'))
```

Exercises

Exercise 1 - Relationship between parental education level and student grades

```
# your code here
```

Exercise 2 - Impact of internet access at home on grades

```
# your code here
```

Exercise 3 - Explore LLM's code

Can you find what code the model used to generate the plot for exploring the relationship between absences and academic performance?

You could run the corresponding code and from the response chain, you could see the code used from charting.

```
# your code here

# the code that model use here
```

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<!--## Change Log--!>

<!--	Date (YYYY-MM-DD)	Version	Changed By
2024-05-10	0.2	Kang Wang & Wojciech Fulmyk	Initial version created
2024-02-23	0.1	Elio Di Nino	Update library documentation