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Artificial Intelligence Engineering (Level-1)

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Digital Space

Level-1

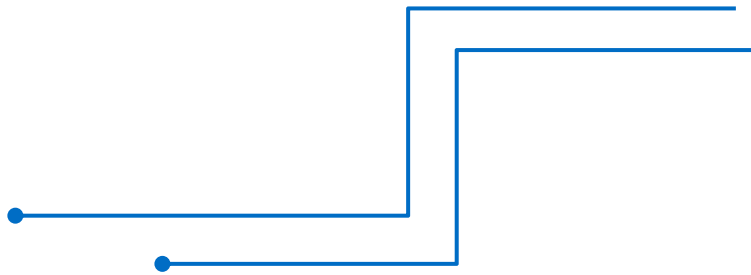
- Module 1: Introduction to AI and Machine Learning
- Module 2: Linear Algebra, Statistics and Probability for AI
- Module 3: Neural Network Architecture
- Module 4: Building Machine Learning Models
- Module 5: Deep Learning Concepts
- Module 6: Python Data Structure
- Module 7: Data Handling with Pandas and NumPy
- Module 8: Python for AI
- Module 9: Classification AI Project
- Module 10: Prediction AI Project

Artificial Intelligence Engineering (Level-1)

Module 7: Data Handling with Pandas and NumPy

Content

- Numpy
- Pandas
- Data Handling and Manipulation
  - Loading Data
  - Data Exploration
  - Data Cleaning
  - Data Transformation
  - Statistical Analysis
  - Visualization



Learning Outcomes

- Master NumPy Fundamentals: Learn to create and manipulate arrays for efficient numerical computations.
- Understand Pandas Basics: Use Pandas for data manipulation, including creating and modifying DataFrames and Series.
- Efficient Data Handling: Load, handle, and manipulate structured and unstructured data effectively.
- Learn Data Loading Techniques: Import data from various formats (CSV, Excel, databases) into Python for analysis.
- Explore Data: Perform exploratory data analysis to uncover patterns, trends, and insights in datasets.

Learning Outcomes

- Clean Data: Identify and handle missing, incorrect, or irrelevant data to prepare it for analysis.
- Transform Data: Apply techniques to normalize, aggregate, or restructure data for better usability.
- Perform Statistical Analysis: Apply statistical methods to summarize and infer information from data.
- Visualize Data: Create informative and visually appealing charts and graphs using libraries like Matplotlib or Seaborn.
- Prepare Data for Machine Learning: Develop skills to preprocess and transform data for use in machine learning models.

Why Data Handling is important

- **Decision Making**
  - Accurate data enables informed and strategic decisions.
- **Problem Solving**
  - Helps identify trends and patterns to address challenges effectively.
- **Organized Information**
  - Simplifies complex data into manageable formats.
- **Enhanced Efficiency**
  - Saves time and resources by optimizing data processes.
- **Compliance and Security**
  - Ensures data integrity and adheres to regulations.

NumPy Practices

What is NumPy?

- NumPy (Numerical Python) is a **powerful open-source library in Python** used for numerical and scientific computing.
- It provides support for working with large, multi-dimensional arrays and matrices, along with a collection of mathematical functions to operate on these data structures efficiently.

Key Features:

- Supports multi-dimensional arrays
- Provides mathematical functions for array operations
- Efficient memory usage

NumPy Array Vs Python Lists

Feature	NumPy Arrays	Python Lists
Data Type Consistency	Stores elements of the same data type.	Can store mixed data types in one list.
Performance	Faster due to optimized C-based operations.	Can store mixed data types in one list.
Memory Usage	More memory-efficient.	Less efficient as it stores metadata for each element.
Mathematical Operations	Supports element-wise operations directly.	Requires manual loops or map functions.
Multidimensional Data	Supports multi-dimensional arrays (e.g., 2D, 3D).	Requires nested lists for multidimensional data.
Ease of Use	Designed for numerical computations.	General-purpose and simpler for non-mathematical tasks.

How to import NumPy

- Before importing, ensure **NumPy is installed** in your Python environment. Use the following command to install it:

```
C:\Users\User>pip install numpy
Collecting numpy
  Downloading numpy-2.1.3-cp313-cp313-win_amd64.whl.metadata (60 kB)
Downloading numpy-2.1.3-cp313-cp313-win_amd64.whl (12.6 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 12.6/12.6 MB 6.7 MB/s eta 0:00:00
Installing collected packages: numpy
Successfully installed numpy-2.1.3

[notice] A new release of pip is available: 24.2 -> 24.3.1
[notice] To update, run: python.exe -m pip install --upgrade pip

C:\Users\User>
```

- To use the NumPy library in Python, you need to **import** it. The standard way to import NumPy is:

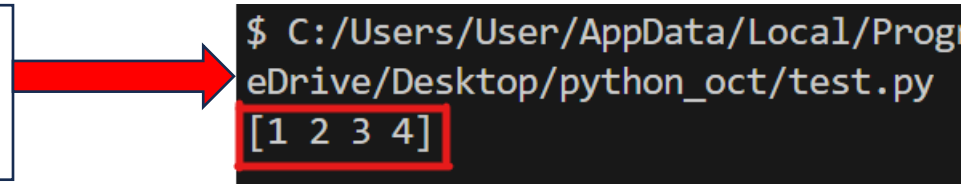
```
import numpy as np
```

NumPy Basic

- **Creating Array**

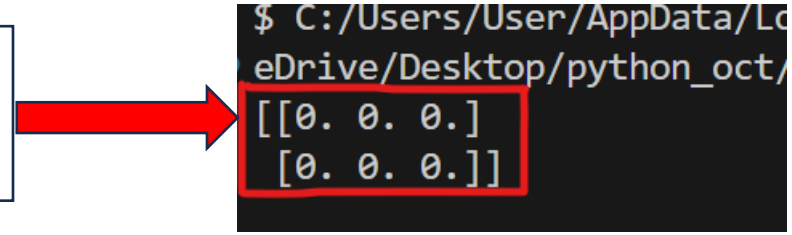
np.array(): Converts a list or tuple into a NumPy array.

```
arr = np.array([1, 2, 3, 4])
print(arr)
```



np.zero(): Creates an array filled with zeros.

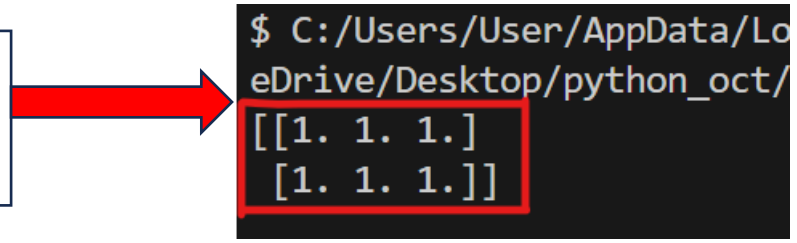
```
zeros = np.zeros((2, 3))
print(zeros)
```



NumPy Basic

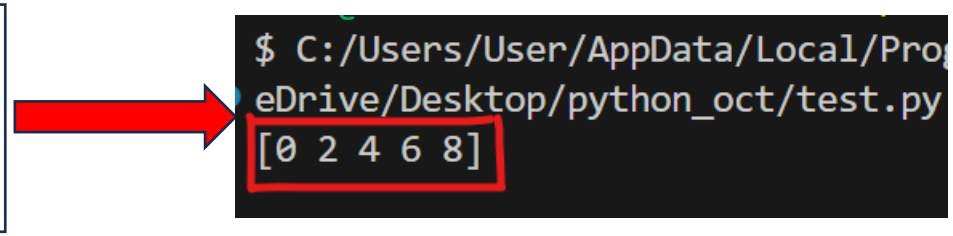
np. one(): Creates an array filled with ones.

```
ones = np.ones((2, 3))
print(ones)
```



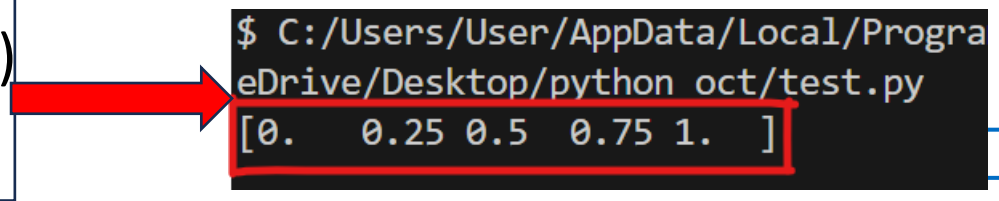
np.arange(): Creates an array with a range of values.

```
arange_array = np.arange(0, 10, 2)
print(arange_array)
```



np.linspace(): Creates an array with evenly spaced values.

```
linspace_array = np.linspace(0, 1, 5)
print(linspace_array)
```

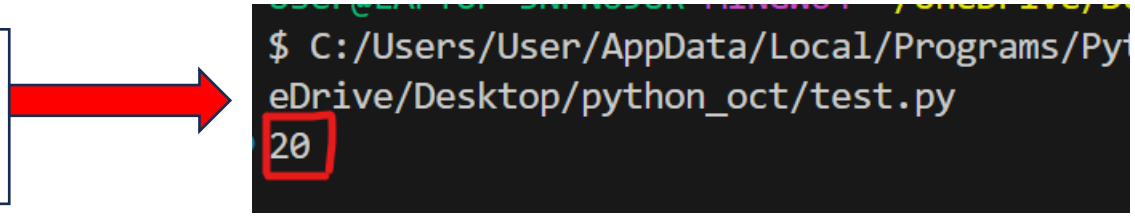


NumPy Basic

- Accessing elements, slicing, and indexing.

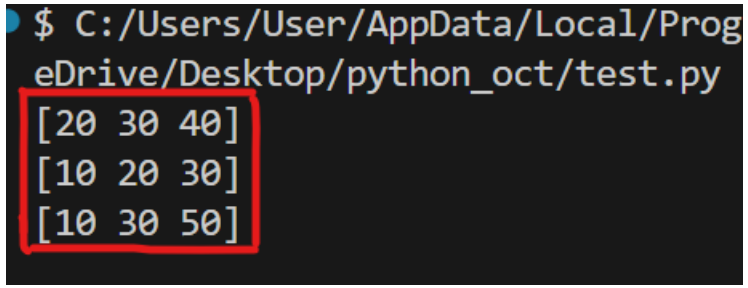
Accessing elements

```
arr = np.array([10, 20, 30, 40, 50])
print(arr[1])
```



Slicing

```
arr = np.array([10, 20, 30, 40, 50])
print(arr[1:4])
print(arr[:3])
print(arr[::2])
```



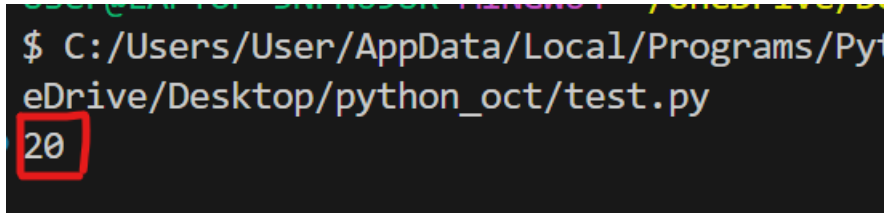
NumPy Basic

- **Accessing elements, slicing, and indexing**

1	2	3
4	5	6
7	8	9

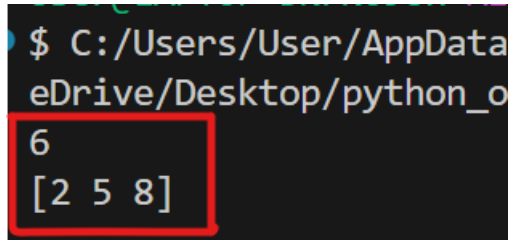
Indexing in Multi-dimensional Arrays

```
arr = np.array([10, 20, 30, 40, 50])
print(arr[1])
```



Slicing

```
matrix = np.array([[1, 2, 3],
        [4, 5, 6], [7, 8, 9]])
print(matrix[1, 2])
print(matrix[:, 1])
```

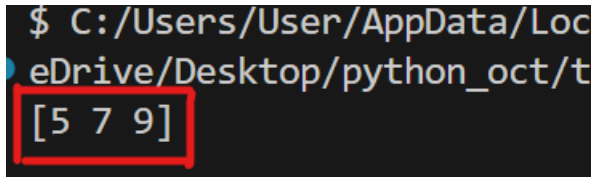


NumPy Operations

- **Array Arithmeic**
  - NumPy allows element-wise operations on arrays, making mathematical computations fast and efficient.

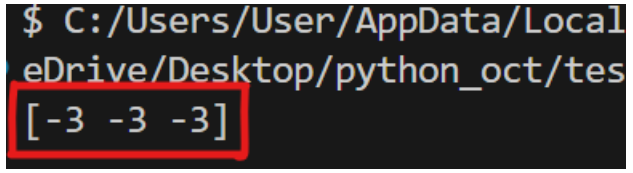
Addition:

```
arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
print(arr1 + arr2)
```



Subtraction:

```
arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
print(arr1 - arr2)
```



NumPy Operations

Array Arithmeic

Multiplication:

```
arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
print(arr1 * arr2)
```

```
$ C:/Users/User/AppData/Local/Prog
eDrive/Desktop/python_oct/test.py
[ 4 10 18]
```

Division:

```
arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
print(arr1 / arr2)
```

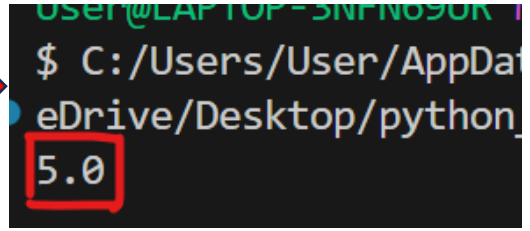
```
$ C:/Users/User/AppData/Loca
eDrive/Desktop/python_oct/te
[0.25 0.4  0.5 ]
```

NumPy Operations

- **Mathematical Functions**
  - NumPy provides built-in functions for common mathematical operations:

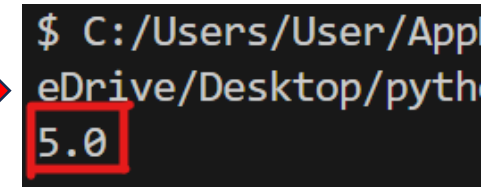
Mean: Average value.

```
arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
print(np.mean(arr2))
```



Median: Middle value.

```
arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
print(np.median(arr2))
```

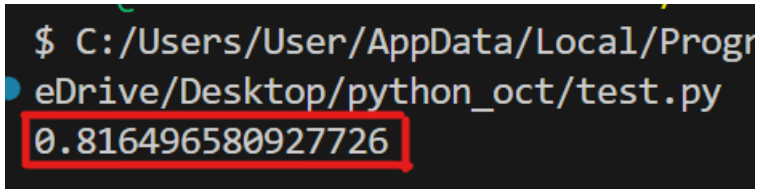


NumPy Operations

- **Mathematical Functions**

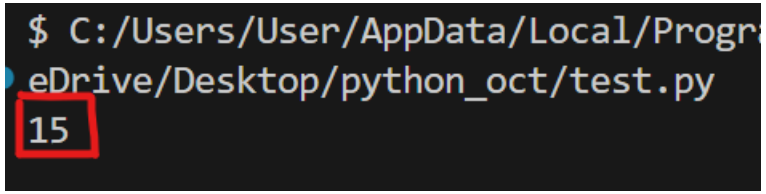
Standard Deviation: Measures the spread of data.

```
arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
print(np.std(arr2))
```



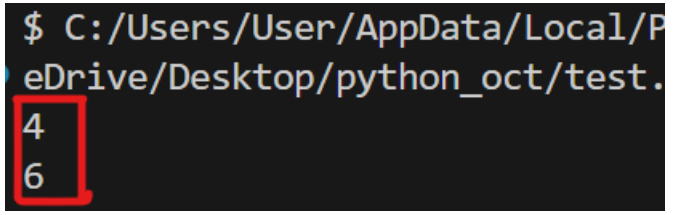
Sum: Total of all elements.

```
arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
print(np.sum(arr2))
```



Minimum and Maximum: Smallest and largest elements.

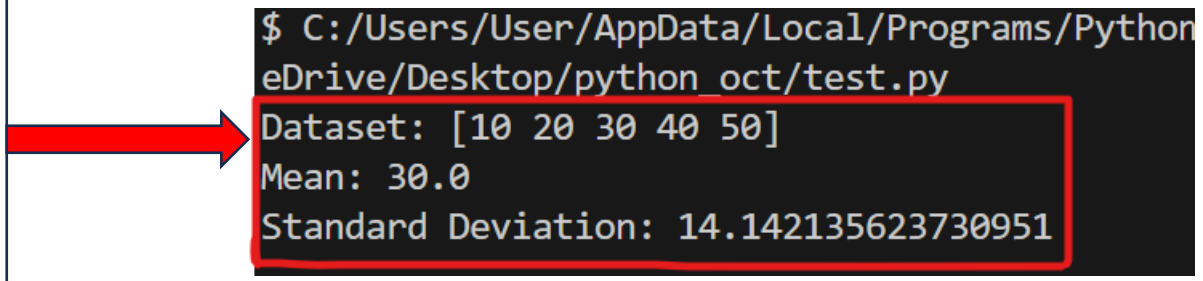
```
arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
print(np.min(arr2))
print(np.max(arr2))
```



NumPy Operations

Example: Finding the Mean and Standard Deviation

```
import numpy as np
# Dataset
data = np.array([10, 20, 30, 40, 50])

# Calculating mean and standard deviation
mean = np.mean(data)
std_dev = np.std(data)
 print("Dataset:", data)
 print("Mean:", mean) print("Standard
Deviation:", std_dev)
```



Standard Deviation

Formula for Standard Deviation:

For an array x with n elements:

$$\text{Standard Deviation} = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \text{mean})^2}{n}}$$

arr2 = np.array([4, 5, 6])

Steps for `arr2`:

1. **Find the Mean:**

$$\text{Mean} = \frac{4+5+6}{3} = 5$$

2. **Calculate Deviations from the Mean:**

$$\text{Deviations} = [4-5, 5-5, 6-5] = [-1, 0, 1]$$

3. **Square the Deviations:**

$$\text{Squared Deviations} = [-1^2, 0^2, 1^2] = [1, 0, 1]$$

4. **Find the Mean of the Squared Deviations:**

$$\text{Mean of Squared Deviations} = \frac{1+0+1}{3} = \frac{2}{3} \approx 0.6667$$

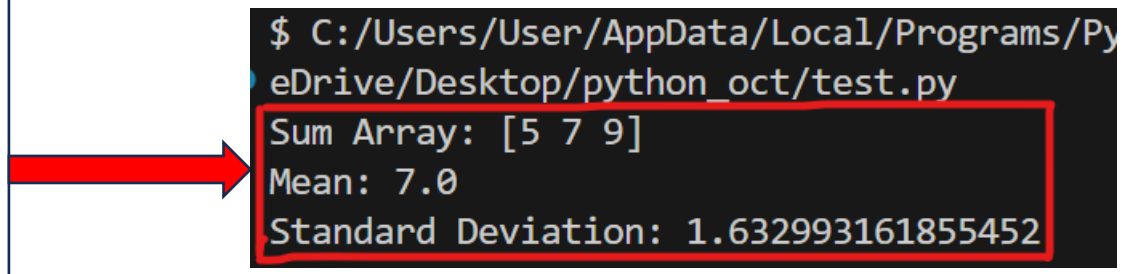
5. **Take the Square Root:**

$$\text{Standard Deviation} = \sqrt{0.6667} \approx 0.8165$$

NumPy Operations

Example: Combining Array Creation and Operations

```
import numpy as np
# Create arrays
arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])

# Perform operations
sum_array = arr1 + arr2
mean_value = np.mean(sum_array)
std_dev = np.std(sum_array)

# Print results
print("Sum Array:", sum_array)
print("Mean:", mean_value)
print("Standard Deviation:", std_dev)
```



Pandas Practices

What is Pandas?

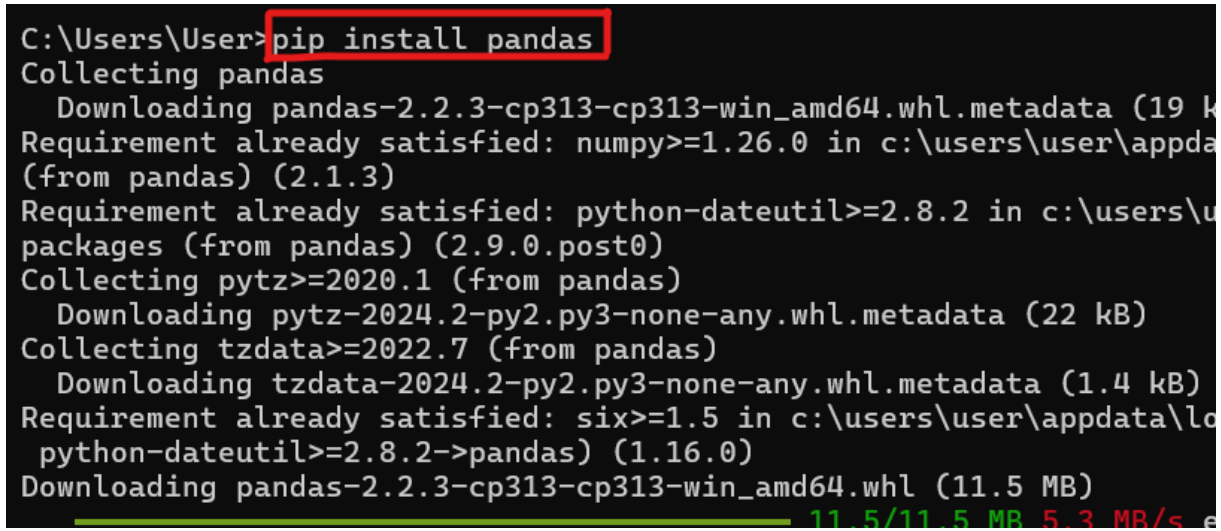
- Pandas is a **Python library** used for **data manipulation and analysis**. It provides high-level data structures and tools to work efficiently with structured data, such as **tabular data**, **time-series data**, and **multidimensional data**.

Key Features:

- Data structures: Series and DataFrames.
- Data cleaning, transformation, and analysis.
- Reading and writing data from different file formats (CSV, Excel, JSON, etc.).

How to import NumPy

- Before importing, ensure **pandas is installed** in your Python environment. Use the following command to install it:



- To use the **pandas** library in Python, you need to **import** it. The standard way to import **pandas** is:

```
import pandas as pd
```

Pandas Series

- A **Pandas Series** is a **one-dimensional labeled array** capable of holding data of any type (integer, float, string, etc.). It is similar to a column in a spreadsheet or a Python list, but with labels (called an **index**) that make it more powerful.

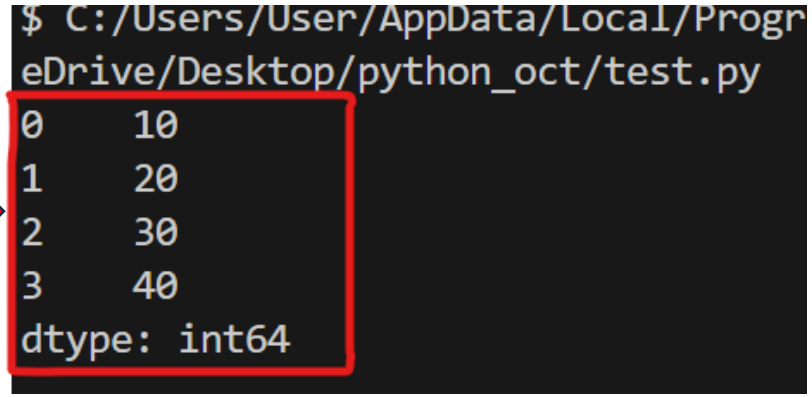
Pandas Series can be created from:

- Python lists
- NumPy arrays
- Dictionaries

Pandas Series

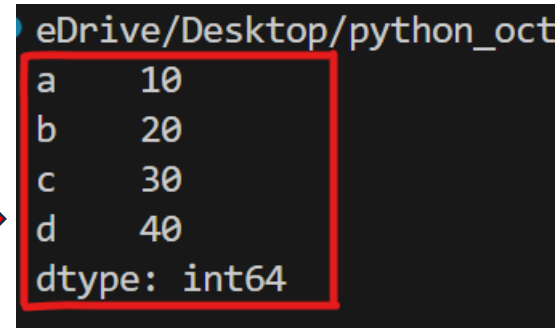
Example : Creating a Series from a List

```
import pandas as pd

# Create a Series from a list
data = [10, 20, 30, 40]
series = pd.Series(data)
print(series)
```



Example : Adding Custom Index Labels

```
# Create a Series with custom index
data = [10, 20, 30, 40]
series = pd.Series(data, index=['a', 'b', 'c', 'd'])
print(series)
```



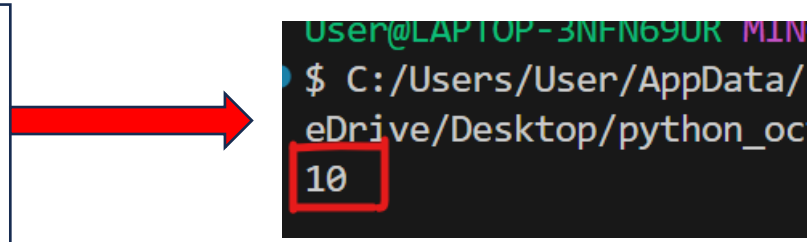
Pandas Series

Indexing and Slicing

- Pandas Series allows access to elements using labels or positions, similar to Python lists.

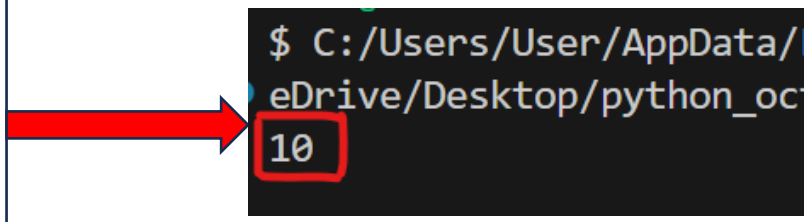
Indexing with position

```
# Access the first element
data = [10, 20, 30, 40]
series = pd.Series(data)
print(series[0])
```



Indexing with Labels

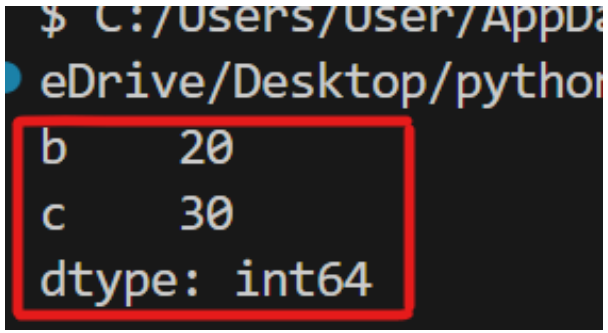
```
# Access an element using a label
data = [10, 20, 30, 40]
 series = pd.Series(data, index=['a', 'b', 'c', 'd'])
print(series['a'])
```



Pandas Series

Slicing

```
Import pandas as pd


# Access the first element
data = [10, 20, 30, 40]
series = pd.Series(data)
print(series[0])
```

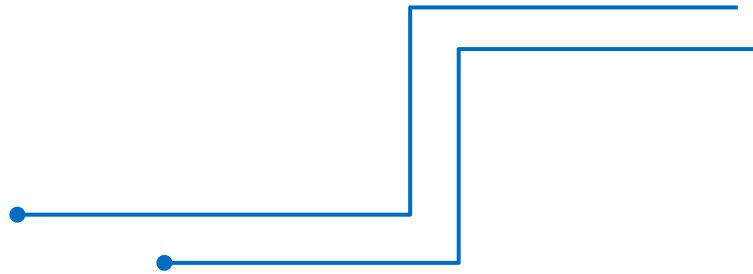


Pandas

Example: Creating a Pandas Series and Accessing Elements

```
import pandas as pd
# Create a Series
data = [100, 200, 300, 400, 500]
index_labels = ['Math', 'Science',
'English’,'History', 'Geography']
grades = pd.Series(data,index=index_labels)

# Print the Series
print("Series:")
print(grades)

# Access specific elements
print("\nGrade in Science:",grades['Science'])
print("Grade in English:", grades['English'])
```

```
# Slice a range
print("\nGrades from
Science to History:")

print(grades['Science':
'History’])
```



Pandas

Output

```
$ C:/Users/User/AppData/Local/Programs/Python
eDrive/Desktop/python_oct/test.py
Series:
Math          100
Science       200
English       300
History       400
Geography     500
dtype: int64

Grade in Science: 200
Grade in English: 300

Grades from Science to History:
Science    200
English    300
History    400
dtype: int64
```

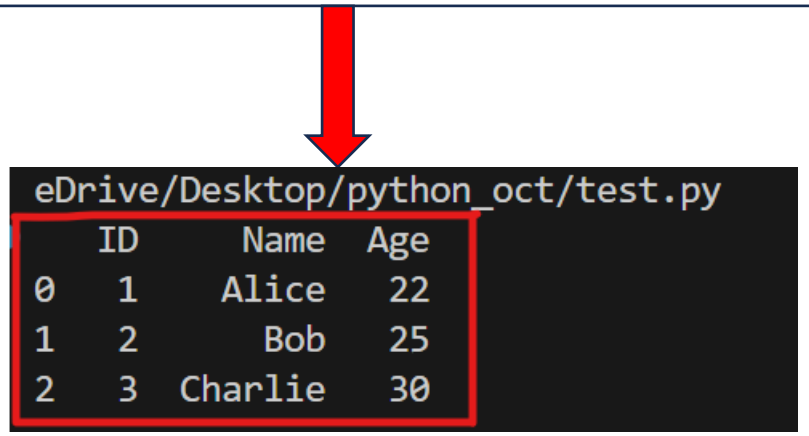
Pandas Data Frame

- A **Pandas Data Frame** is a two-dimensional, tabular data structure in Python that is similar to an Excel spreadsheet or SQL table.
- It is part of the Pandas library and is widely used for data manipulation, analysis, and visualization.

Pandas

Example : Creating data frame from list

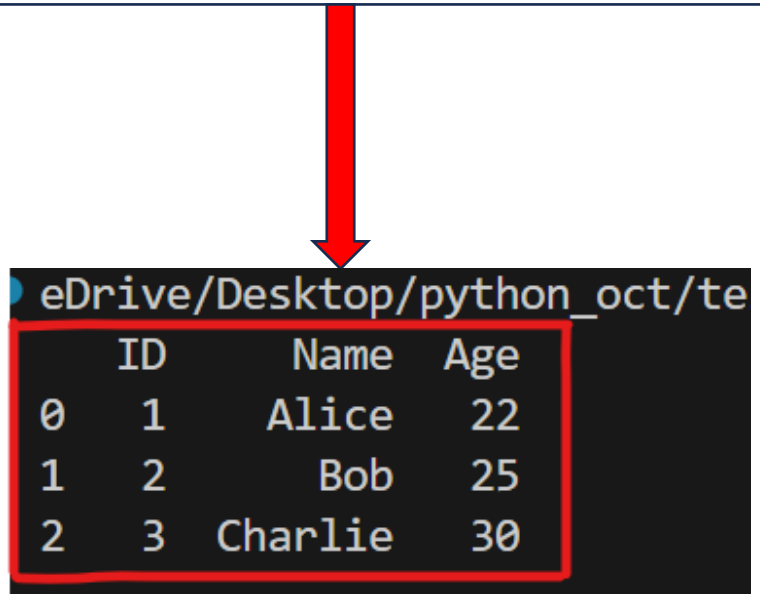
```
import pandas as pd

data = [[1, 'Alice', 22], [2, 'Bob', 25], [3, 'Charlie', 30]]

df = pd.DataFrame(data,columns=['ID', 'Name', 'Age’])

print(df)
```



Pandas

Example : Creating data frame from Dictionaries

```
import pandas as pd
data = {'ID': [1, 2, 3], 'Name': ['Alice', 'Bob', 'Charlie'],
        'Age': [22, 25, 30]}
df = pd.DataFrame(data)
print(df)
```

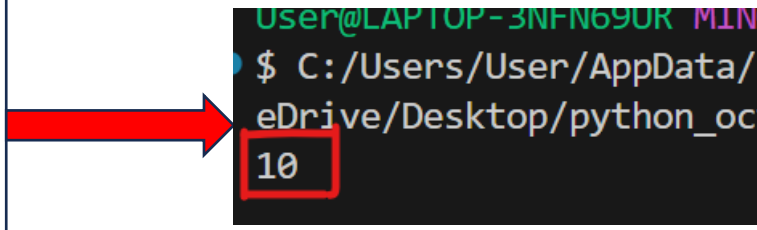


Pandas

Accessing Rows and Columns

Using .loc[](label-based)

```
import pandas as pd

data = {'ID': [1, 2, 3],
        'Name': ['Alice', 'Bob', 'Charlie'],
        'Age': [22, 25, 30]}
df = pd.DataFrame(data)

# Access a specific row
print(df.loc[1])

# Access a specific cell
print(df.loc[1, 'Name'])
```



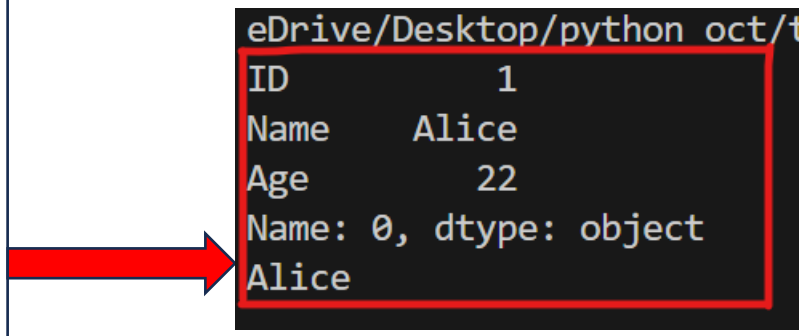
Pandas

Accessing Rows and Columns

ID	Name	Age
1	Alice	22
2	Bob	25
3	Charlie	30

Using .iloc[](Position-based)

```
import pandas as pd

data = {'ID': [1, 2, 3],
        'Name': ['Alice', 'Bob', 'Charlie'],
        'Age': [22, 25, 30]}
df = pd.DataFrame(data)

# Access a specific row
print(df.iloc[0])  # First row
# Access a specific cell
print(df.iloc[0, 1])  # Cell at position [0, 1]
(first row, second column)
```



Loading Data into Pandas

Reading CSV, Excel, and JSON Files with Pandas	
pd.read_csv()	loads data from a CSV file.
pd.read_excel()	loads data from an Excel file.
pd.read_json()	loads data from a JSON file.

Loading Data into Pandas(Loading CSV Data)

sample_data.csv

```
Name,Age,Department,Salary
Alice,30,HR,50000 Bob,25,IT,55000
Charlie,35,Finance,60000
David,28,IT,58000 Eva,32,HR,52000
```

reading_data.py

```
import pandas as pd

# Reading CSV file
df_csv = pd.read_csv('sample_data.csv')
print("CSV Data:")
print(df_csv.head()) # Display the
first 5 rows
```

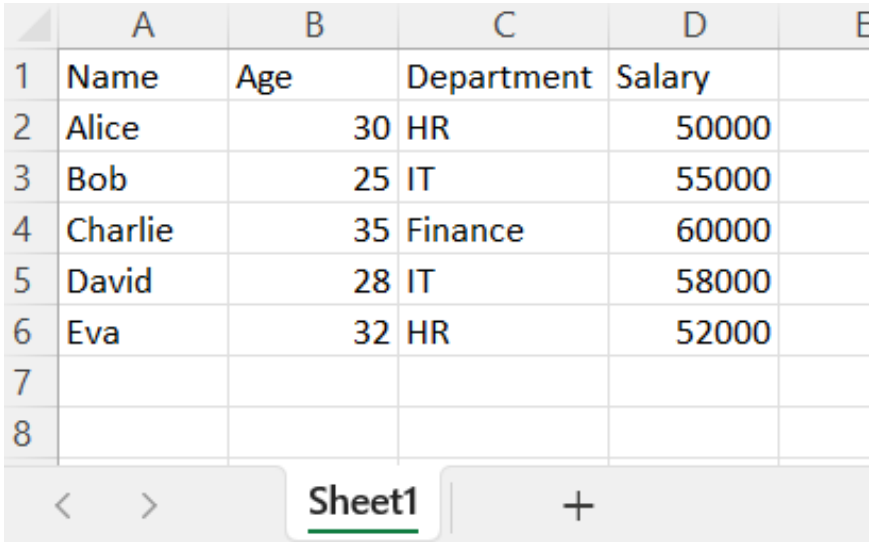
Output

```
CSV Data:
      Name  Age Department  Salary
1      Bob   25         IT   55000
2  Charlie   35    Finance   60000
3    David   28         IT   58000
4      Eva   32         HR   52000
```

Loading Data into Pandas(Loading Excel Data)

pd.read_excel() loads data from an Excel file.

sample_data.xlxs



	A	B	C	D	E
1	Name	Age	Department	Salary	
2	Alice	30	HR	50000	
3	Bob	25	IT	55000	
4	Charlie	35	Finance	60000	
5	David	28	IT	58000	
6	Eva	32	HR	52000	
7					
8					

Sheet1

reading_data.py

```
import pandas as pd

# Reading Excel file
df_excel = pd.read_excel('sample_data.xlsx’,
sheet_name='Sheet1')
print("\nExcel Data:")
print(df_excel.head())
```

Output

```
Excel Data:
      Name  Age Department  Salary
0    Alice   30         HR   50000
1      Bob   25         IT   55000
2  Charlie   35    Finance   60000
3    David   28         IT   58000
4      Eva   32         HR   52000
```

Loading Data into Pandas(Loading JSON Data)

sample_data.json

```
[
    {"Name": "Alice", "Age": 30, "Department": "HR", "Salary": 50000},
    {"Name": "Bob", "Age": 25, "Department": "IT", "Salary": 55000},
    {"Name": "Charlie", "Age": 35, "Department": "Finance", "Salary":
60000},
    {"Name": "David", "Age": 28, "Department": "IT", "Salary": 58000},
    {"Name": "Eva", "Age": 32, "Department": "HR", "Salary": 52000}
]
```

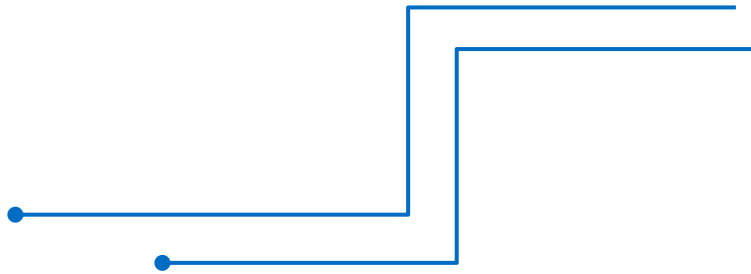
reading_data.py

```
import pandas as pd

# Reading JSON file
df_json = pd.read_json('sample_data.json')
print("\nJSON Data:")
print(df_json.head())
```

Loading Data into Pandas(Loading JSON Data)

Output

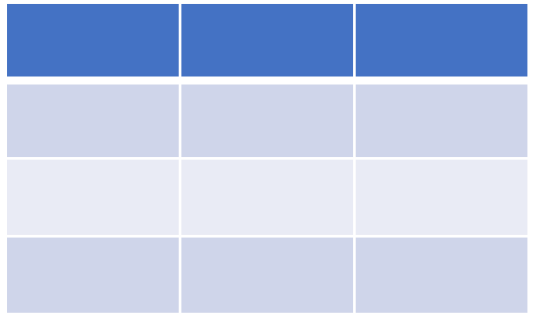
```
JSON Data:
      Name  Age Department  Salary
0    Alice   30         HR   50000
1      Bob   25         IT   55000
2  Charlie   35    Finance   60000
3    David   28         IT   58000
4      Eva   32         HR   52000
```



Explore the Data Frame

Explore the Data Frame	
.head() , .tail()	show the first and last 5 rows, respectively.
.info()	provides a summary of the Data Frame.
.describe()	gives a statistical summary (only for numerical columns).
.shape ()	returns the number of rows and columns.
.isnull() , .sum()	helps to identify missing values.
.fillna()	fills missing values with a specified value.
.dropna()	removes rows with missing values.

Explore the Data Frame



Data Profiling/ Review/ Data Preprocessing

ELT (Extract, Load, Transform)
or ETL (Extract, Transform, Load)

Explore the Data Frame

Sample Data Frame

```
# Sample DataFrame for demonstration
data = {
   'Name': ['Alice', 'Bob', 'Charlie', 'David', 'Eva'],
   'Age': [25, 30, 35, None, 28],
   'Salary': [50000, 60000, None, 70000, 65000]
}
df = pd.DataFrame(data)
```

Display first few rows & last few rows

```
# Display first few rows
print("Head of the DataFrame:")
print(df.head())

# Display last few rows
print("\nTail of the DataFrame:")
print(df.tail())
```

Output

```
Head of the DataFrame:
      Name   Age   Salary
0    Alice  25.0  50000.0
1      Bob  30.0  60000.0
2  Charlie  35.0      NaN
3    David   NaN  70000.0
4      Eva  28.0  65000.0
```

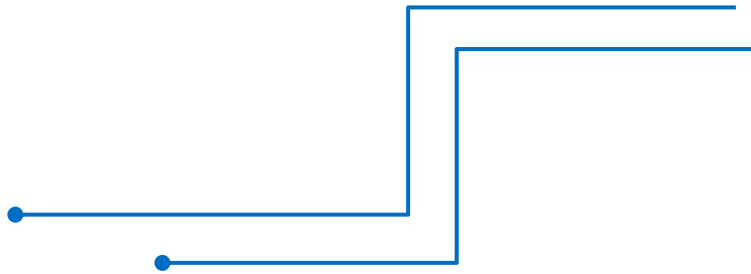
```
Tail of the DataFrame:
      Name   Age   Salary
0    Alice  25.0  50000.0
1      Bob  30.0  60000.0
2  Charlie  35.0      NaN
3    David   NaN  70000.0
4      Eva  28.0  65000.0
```

Explore the Data Frame

Example

Sample Data Frame

```
# Sample DataFrame for demonstration
data = {
   'Name': ['Alice', 'Bob', 'Charlie', 'David', 'Eva'],
   'Age': [25, 30, 35, None, 28],
   'Salary': [50000, 60000, None, 70000, 65000]
}
df = pd.DataFrame(data)
```



Explore the Data Frame

```
# Display first few rows
print("Head of the DataFrame:")
print(df.head())

# Display last few rows
print("\nTail of the DataFrame:")
print(df.tail())

# Display information about the DataFrame
print("\nDataFrame Info:")
df.info()

# Display statistical summary
print("\nStatistical Summary:")
print(df.describe())
```

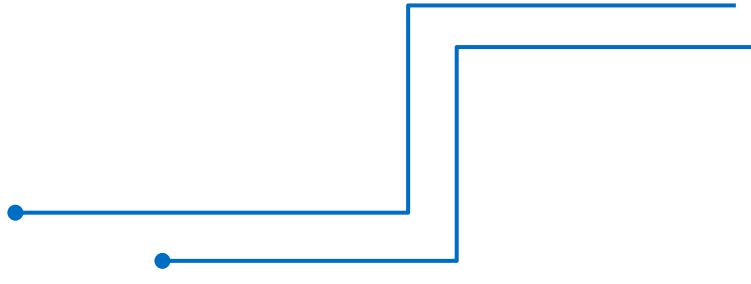
```
# Checking the shape of the DataFrame (rows, columns)
print("\nShape of DataFrame:", df.shape)

# Checking for missing values
print("\nMissing Values:")
print(df.isnull().sum())

# Handling missing values
df_filled = df.fillna(0)
print("\nDataFrame after filling missing values:")
print(df_filled)
df_dropped = df.dropna()
print("\nDataFrame after dropping missing values:")
print(df_dropped)
```

Explore the Data Frame

Output

```
Head of the DataFrame:
      Name   Age   Salary
0    Alice  25.0  50000.0
1      Bob  30.0  60000.0
2  Charlie  35.0      NaN
3    David   NaN  70000.0
4      Eva  28.0  65000.0

Tail of the DataFrame:
      Name   Age   Salary
0    Alice  25.0  50000.0
1      Bob  30.0  60000.0
2  Charlie  35.0      NaN
3    David   NaN  70000.0
4      Eva  28.0  65000.0
```

```
Shape of DataFrame: (5, 3)

Missing Values:
Name      0
Age       1
Salary    1
dtype: int64

DataFrame after filling missing values:
      Name   Age   Salary
0    Alice  25.0  50000.0
1      Bob  30.0  60000.0
2  Charlie  35.0      0.0
3    David   0.0  70000.0
4      Eva  28.0  65000.0

DataFrame after dropping missing values:
    Name   Age   Salary
0  Alice  25.0  50000.0
1    Bob  30.0  60000.0
4    Eva  28.0  65000.0
```



Data Cleansing

Data Cleansing	
.drop_duplicates()	removes duplicate rows from the DataFrame.
np.percentile()	calculates a specific percentile value to identify potential outliers.

Data Cleansing

Example: Data Cleansing

```
import pandas as pd

data_dup = {
    'Name': ['Alice', 'Bob', 'Charlie', 'Alice', 'Bob'],
    'Age': [25, 30, 35, 25, 30]}
df_dup = pd.DataFrame(data_dup)
```

```
# Removing duplicates
df_no_duplicates =
df_dup.drop_duplicates()
print("DataFrame after removing
duplicates:")
print(df_no_duplicates)
```

Output

```
DataFrame after removing duplicates:
      Name  Age
0    Alice   25
1      Bob   30
2  Charlie   35
```

Data Transformation

Sorting and Filtering Data

- Sorting helps to arrange data based on specific columns.
- Filtering extracts subsets of data based on conditions.

Sorting and Filtering Data	
.sort_values()	Sorts the DataFrame based on a specific column.
.query()	filters the DataFrame based on conditions.
.groupby().agg()	performs grouping and aggregation.
pd.merge()	merges two DataFrames on a common key.
pd.concat()	concatenates DataFrames along a specified axis.

Data Transformation(Sorting and Filtering Data)


```
import pandas as pd
# Sample DataFrame
data_transform = {
    'Name': ['Alice', 'Bob', 'Charlie', 'David', 'Eva'],
    'Department': ['HR', 'Finance', 'IT', 'IT', 'HR'],
    'Salary': [50000, 60000, 55000, 70000, 65000]}
df_transform = pd.DataFrame(data_transform)
```

```
# Sorting by Salary
df_sorted = df_transform.sort_values(by='Salary', ascending=False)
print("DataFrame sorted by Salary:")
print(df_sorted)
# Filtering: IT Department with Salary > 55000
df_filtered = df_transform.query("Department == 'IT' and Salary > 55000")
print("\nFiltered DataFrame (IT Department with Salary > 55000):")
print(df_filtered)
```

Data Transformation(Sorting and Filtering Data)

Output

```
      Name Department  Salary
3    David         IT   70000
4      Eva         HR   65000
1      Bob    Finance   60000
2  Charlie         IT   55000
0    Alice         HR   50000

Filtered DataFrame (IT Department with Salary > 55000):
    Name Department  Salary
3  David         IT   70000
```

Data Transformation

Grouping and Aggregation

- Grouping combines rows with the same value in a column and applies aggregations.

Grouping and Aggregarion	
.groupby().agg()	performs grouping and aggregation.

Data Transformation(Grouping and Aggregation)

```
import pandas as pd

# Sample DataFrame
data_transform = {
    'Name': ['Alice', 'Bob', 'Charlie', 'David', 'Eva'],
    'Department': ['HR', 'Finance', 'IT', 'IT', 'HR'],
    'Salary': [50000, 60000, 55000, 70000, 65000]}
df_transform = pd.DataFrame(data_transform)
```

```
# Grouping by Department and calculating average Salary
df_grouped = df_transform.groupby('Department').agg({'Salary': 'mean'})
print("\nAverage Salary by Department:")
print(df_grouped)
```

Data Transformation(Grouping and Aggregation)

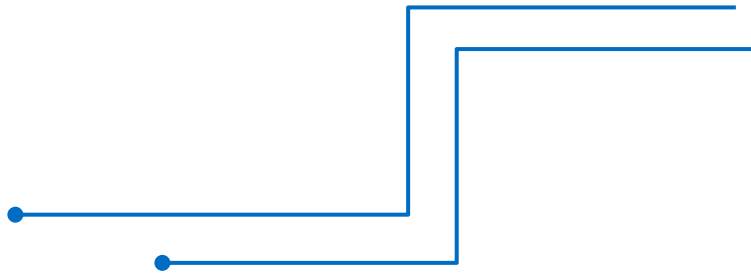
Output

```
Average Salary by Department:
              Salary
Department
Finance      60000.0
HR           57500.0
IT           62500.0
HR           57500.0
HR           57500.0
IT           62500.0
```

Data Transformation

Merging and Joining Data

Merging and Joining Data	
pd.merge()	merges two DataFrames on a common key.
pd.concat()	concatenates DataFrames along a specified axis.



Data Transformation(Merging and Joining Data)

```
import pandas as pd

# Sample DataFrame
data_transform = {
    'Name': ['Alice', 'Bob', 'Charlie', 'David', 'Eva'],
    'Department': ['HR', 'Finance', 'IT', 'IT', 'HR'],
    'Salary': [50000, 60000, 55000, 70000, 65000]}
df_transform = pd.DataFrame(data_transform)

# Additional data for merging
data_additional = {
    'Name': ['Alice', 'Charlie', 'Eva'],
    'Bonus': [5000, 7000, 6000]}
df_bonus = pd.DataFrame(data_additional)
```

Data Transformation(Merging and Joining Data)


```
# Merging DataFrames
df_merged = pd.merge(df_transform, df_bonus, on='Name',how='left')
print("\nMerged DataFrame with Bonus:")
print(df_merged)
# Concatenating DataFrames
df_concat = pd.concat([df_transform, df_bonus], axis=0)
print("\nConcatenated DataFrame:")
print(df_concat)
```

Output

```
Merged DataFrame with Bonus:
      Name Department  Salary   Bonus
0    Alice         HR   50000  5000.0
1      Bob    Finance   60000     NaN
2  Charlie         IT   55000  7000.0
3    David         IT   70000     NaN
4      Eva         HR   65000  6000.0
```

```
Concatenated DataFrame:
      Name Department   Salary   Bonus
0    Alice         HR  50000.0     NaN
1      Bob    Finance  60000.0     NaN
2  Charlie         IT  55000.0     NaN
3    David         IT  70000.0     NaN
4      Eva         HR  65000.0     NaN
0    Alice        NaN      NaN  5000.0
1  Charlie        NaN      NaN  7000.0
2      Eva        NaN      NaN  6000.0
```

Merging vs. Concatenating

Feature	Merging (`pd.merge`)	Concatenating (`pd.concat`)
Purpose	Combines rows based on common column values.	Stacks DataFrames (row-wise or column-wise).
Key Relationship	Requires a common column for joining.	No relationship required between DataFrames.
Handling Columns	Keeps relevant columns from both DataFrames.	Includes all columns; fills missing values with `NaN` .

Matplotlib Practices

What is matplotlib?

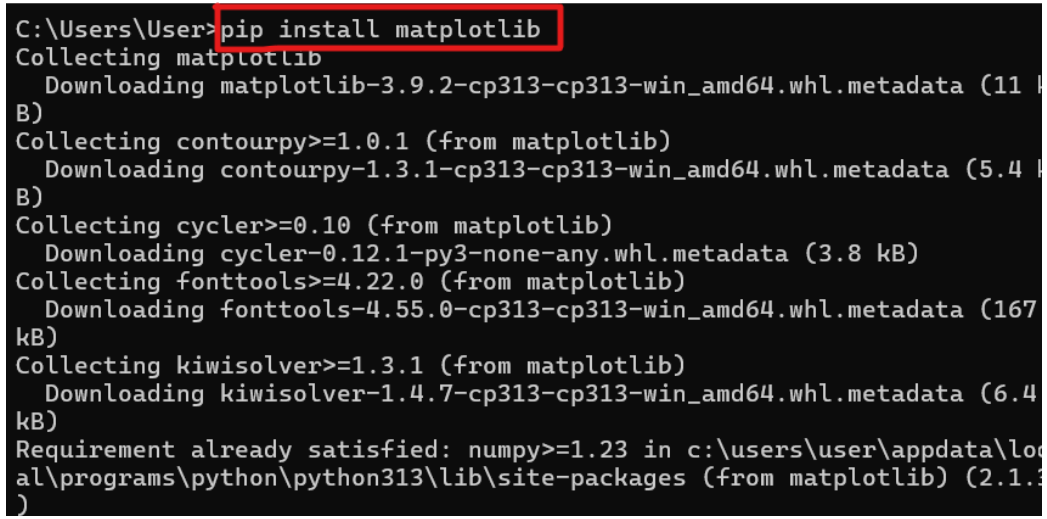
- Matplotlib is a powerful and widely-used Python library for creating visualizations and plots.
- It is especially popular for its versatility and ease of use, making it a cornerstone of the Python data visualization ecosystem.

Features of matplotlib

- **Wide Range of Plot Types**
  - Line plots, scatter plots, bar plots, histograms, pie charts, box plots, heatmaps, etc.
- **Customization**
  - Control over every aspect of a plot (e.g., axis labels, ticks, colors, line styles, markers, legends).
- **Integration**
  - Works seamlessly with libraries like NumPy, Pandas, and SciPy.
- **Publication Quality**
  - High-quality graphics that are suitable for research papers, presentations, and reports.
- **Interactivity**
  - Supports interactive visualizations with tools like zooming and panning.

How to import matplotlib

- To install the **matplotlib** library, which includes the **pyplot** module, you can use the Python package manager **pip**.

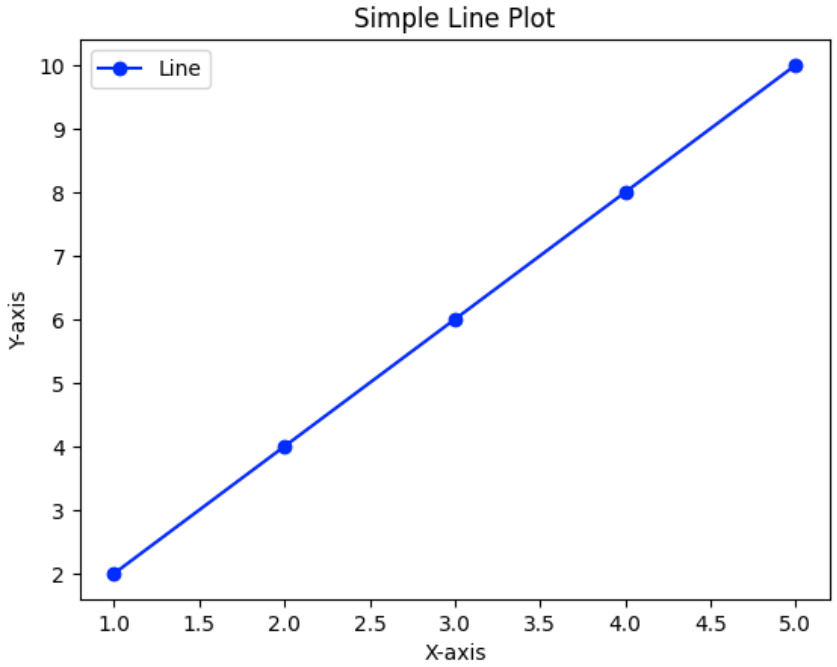


- To use the **matplotlib** library in Python, you need to **import** it. The standard way to import **matplotlib** is:

```
import matplotlib.pyplot as plt
```

Matplotlib Example

```
import matplotlib.pyplot as plt

# Data
x = [1, 2, 3, 4, 5]
y = [2, 4, 6, 8, 10]

# Create a plot
plt.plot(x, y, label='Line', color='blue', marker='o')

# Add labels and title
plt.xlabel('X-axis')
plt.ylabel('Y-axis')
plt.title('Simple Line Plot')
plt.legend()

# Display the plot
plt.show()
```



What is Seaborn?

- Seaborn is a Python data visualization library built on top of Matplotlib.
- It provides an interface for creating attractive and informative statistical graphics with less effort and more features compared to Matplotlib.
- Seaborn is especially useful for visualizing complex relationships between variables and exploring datasets in a statistical context.

Features of Seaborn

- **High-Level Interface**
  - Simplifies the creation of complex visualizations compared to Matplotlib.
- **Built-in Themes**
  - Automatically applies aesthetically pleasing styles to plots.
- **Statistical Visualizations**
  - Provides specialized tools for visualizing distributions, categorical data, and relationships between variables.

Features of Seaborn

- **Integration with Pandas**
  - Works seamlessly with Pandas DataFrames, making it easier to visualize tabular data.
- **Data Aggregation and Summarization**
  - Automatically calculates means, confidence intervals, and other statistical summaries for visualization.
- **Customizability**
  - Offers customization options and works well with Matplotlib for further fine-tuning.

How to import Seaborn

- To install the **Seaborn** library in Python, you can use the Python package manager **pip**.

```
C:\Users\User>pip install seaborn
Collecting seaborn
  Downloading seaborn-0.13.2-py3-none-any.whl.metadata (5.4 kB)
Requirement already satisfied: numpy!=1.24.0,>=1.20 in c:\users\user
pdata\local\programs\python\python313\lib\site-packages (from seabor
(2.1.3)
Requirement already satisfied: pandas>=1.2 in c:\users\user\appdata\
al\programs\python\python313\lib\site-packages (from seaborn) (2.2.3
Requirement already satisfied: matplotlib!=3.6.1,>=3.4 in c:\users\u
\appdata\local\programs\python\python313\lib\site-packages (from sea
n) (3.9.2)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\user\app
a\local\programs\python\python313\lib\site-packages (from matplotlib
.6.1,>=3.4->seaborn) (1.3.1)
Requirement already satisfied: cycler>=0.10 in c:\users\user\appdata
cal\programs\python\python313\lib\site-packages (from matplotlib!=3.
,>=3.4->seaborn) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\user\ap
ta\local\programs\python\python313\lib\site-packages (from matplotli
```

- To use the **Seaborn** library in Python, you need to **import** it. The standard way to import **Seaborn** is:

```
import seaborn as sns
```

Statistical Analysis with Pandas

Calculating Correlation Using .corr()

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

# Sample data
data = {
    'Age': [25, 30, 45, 50, 60],
    'Salary': [50000, 60000, 80000, 90000, 120000],
    'Experience': [2, 4, 10, 12, 15]
}
df = pd.DataFrame(data)
```

Statistical Analysis with Pandas

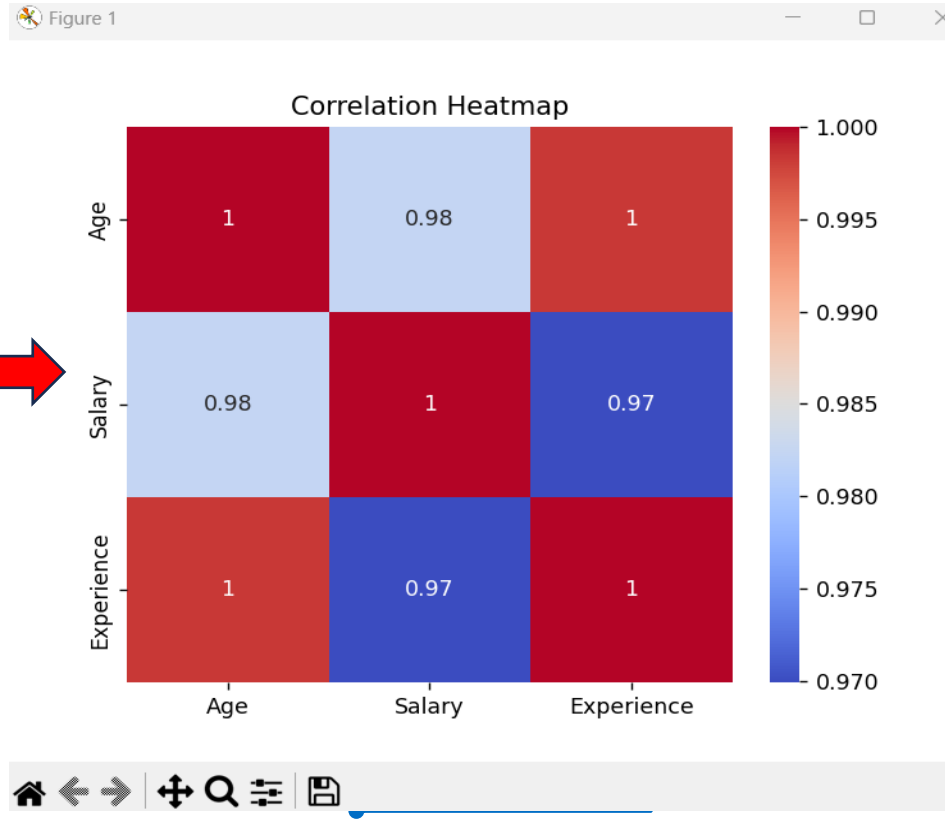
Calculating Correlation using .corr()

```
# Calculate correlation matrix
correlation_matrix = df.corr()
print("Correlation Matrix:")
print(correlation_matrix)
```

Output

```
Correlation Matrix:
                Age    Salary  Experience
Age        1.000000  0.982273    0.998280
Salary     0.982273  1.000000    0.969905
Experience 0.998280  0.969905    1.000000
```

```
# Visualizing correlation
sns.heatmap(correlation_matrix,annot=True,
cmap='coolwarm')
plt.title('Correlation Heatmap')
plt.show()
```



Statistical Analysis with Pandas

Using NumPy Functions with Pandas DataFrames

```
import pandas as pd
import numpy as np

# Sample data
data = {
    'Age': [25, 30, 45, 50, 60],
    'Salary': [50000, 60000, 80000, 90000, 120000],
    'Experience': [2, 4, 10, 12, 15]}
df = pd.DataFrame(data)
```

Statistical Analysis with Pandas

Using NumPy Functions with Pandas DataFrames

```
#Adding a new column with NumPy functions
df['Log_Salary'] = np.log(df['Salary'])
df['Square_Experience'] =
np.square(df['Experience'])
print("DataFrame with new columns:")
print(df)

# Calculate mean and standard deviation
mean_salary = np.mean(df['Salary'])
std_salary = np.std(df['Salary'])

print("\nMean Salary:", mean_salary)
print("Standard Deviation of Salary:",
std_salary)
```

Output

```
DataFrame with new columns:
   Age  Salary  Experience  Log_Salary  Square_Experience
0   25   50000           2   10.819778                  4
1   30   60000           4   11.002100                 16
2   45   80000          10   11.289782                100
3   50   90000          12   11.407565                144
4   60  120000          15   11.695247                225

Mean Salary: 80000.0
Standard Deviation of Salary: 24494.89742783178
```

Visualization using pandas

***Quick Visualizations with* .plot(), .hist(), .boxplot()**

Sample data

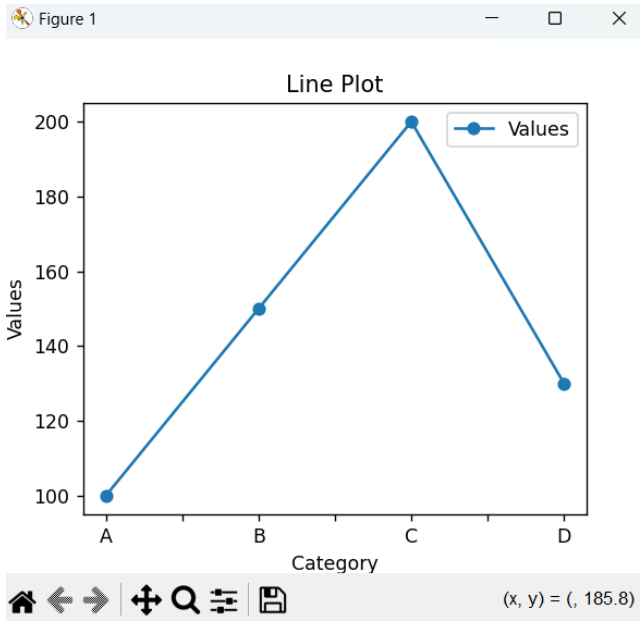
```
import pandas as pd
import matplotlib.pyplot as plt

# Sample data
data = {
    'Age': [25, 30, 45, 50, 60],
    'Salary': [50000, 60000, 80000, 90000, 120000],
    'Experience': [2, 4, 10, 12, 15]}
df = pd.DataFrame(data)
```

Visualization using pandas

Quick Visualizations with Line Plot(.plot())

```
# Line Plot
df_viz.plot(x='Category', y='Values', kind='line',
marker='o')
plt.title('Line Plot')
plt.ylabel('Values')
plt.show()
```

Output

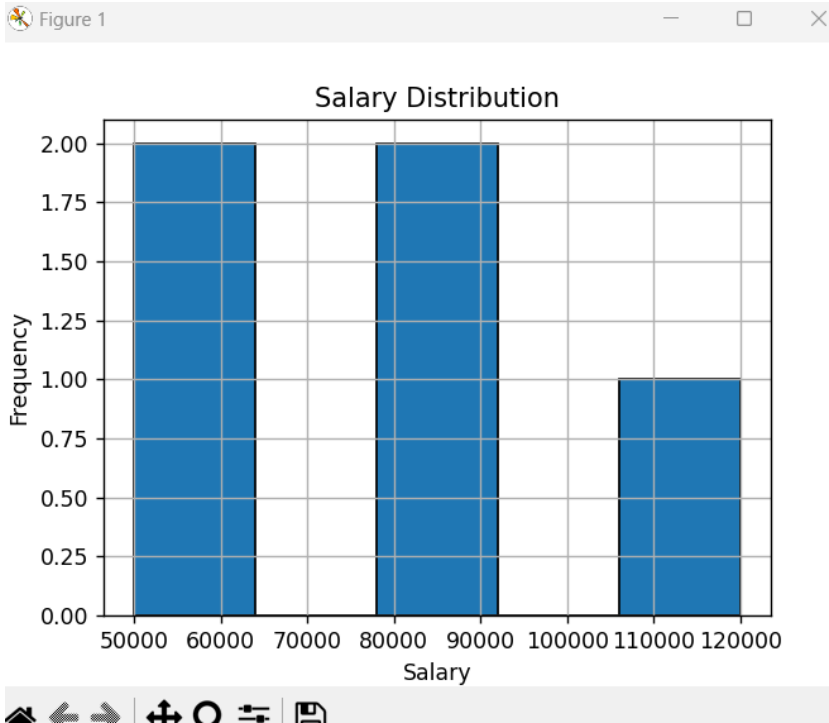


Visualization using pandas

***Quick Visualizations with* Line Plot(.hist())**

```
# Histogram
plt.figure()
df['Salary'].hist(bins=5, edgecolor='black')
plt.title('Salary Distribution')
plt.xlabel('Salary')
plt.ylabel('Frequency')
plt.show()
```

Output

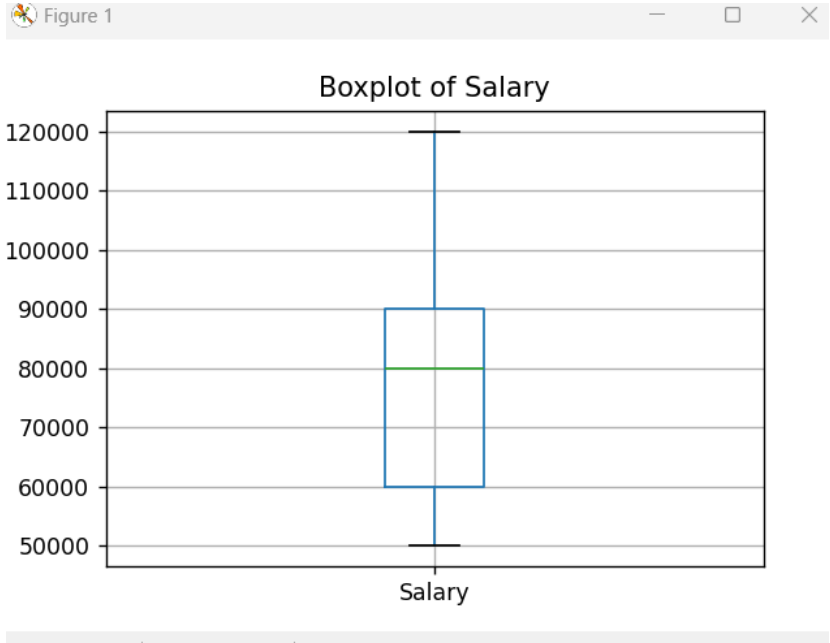


Visualization using pandas

***Quick Visualizations with* Line Plot(.boxplot())**

```
# Boxplot
plt.figure()
df.boxplot(column=['Salary'])
plt.title('Boxplot of Salary')
plt.show()
```

Output



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