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Overview

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Course Highlights

NumPy:
- Efficient numerical computations with multi-dimensional arrays and matrices.
- High-level mathematical functions for handling large datasets.

Pandas:
- Advanced data manipulation and analysis with Series and Data Frames.
- Importing, cleaning, and preprocessing data from various sources.
- Exploratory data analysis and data visualization techniques.

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What You'll Learn

- **Utilize NumPy for efficient array manipulations and mathematical operations.**
- **Employ Pandas for data handling, cleaning, and complex analyses.**
- **Integrate NumPy and Pandas in data science workflows.**
- **Visualize data to effectively communicate insights.**
- **Apply techniques to real-world datasets confidently.**

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Introduction to NumPy

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NumPy (Numerical Python)

- Is a fundamental library for scientific computing in Python.
- It can deal with large data sets.
- It can deal with multi-dimensional arrays.
- It can deal with different types of data.

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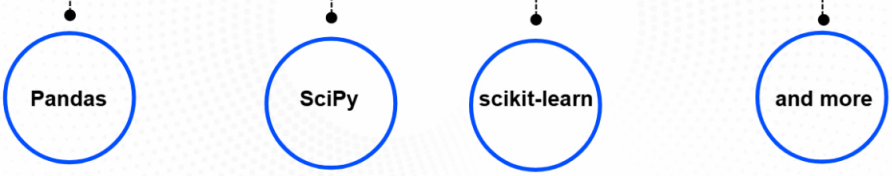
NumPy serves as the backbone for many other Python data science libraries

such as



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Importance of NumPy

- crucial for performing efficient numerical computations
- essential for data analysis, machine learning, and scientific research.

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Key Features NumPy

- **Multi-dimensional array objects (ndarray)**
  - Efficient storage and manipulation of large datasets.
- **Mathematical functions**
  - Comprehensive collection of routines for fast operations on arrays even doe large size arrays.
- **Integration with C/C++**
  - Enables high-performance computations.

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Installing and Importing NumPy

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Installing and Importing NumPy

Installation:
NumPy can be installed using package managers like pip or conda.
Using pip: !pip install numpy
Using conda: conda install numpy

```
# Install NumPy (if not already installed)
!pip install numpy
```

Importing NumPy:
It's a common convention to import NumPy using the alias np.

```
# Import NumPy
import numpy as np
```

Version Check:
You can check the installed version of NumPy using np.____version___.

```
# Check NumPy version
Print ("NumPy Version:", np.___version___)
```

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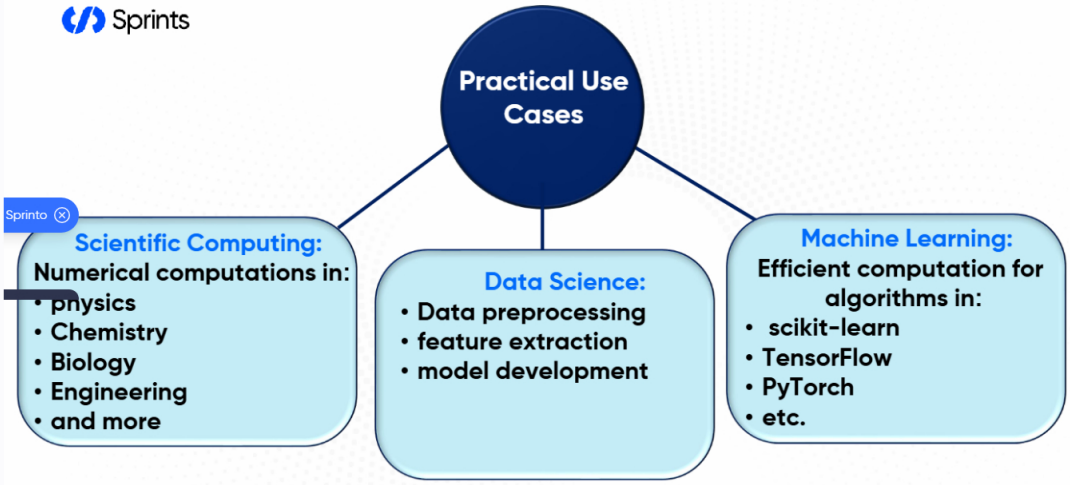

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NumPy Basics

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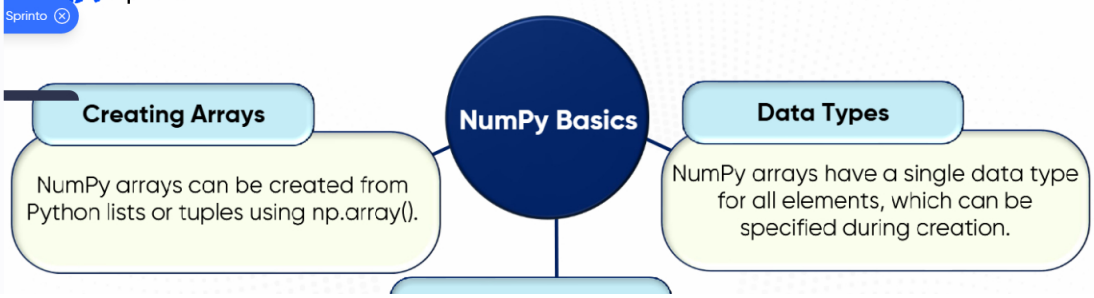

Array Attributes

Understand key attributes like ndim (number of dimensions), shape (size of each dimension), and size (total number of elements).

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Practical Exercise:

Task: Create a one-dimensional and a two-dimensional array, explore their attributes, and perform basic operations.

```
# Creating a one-dimensional NumPy
array from a list
data_1d = [1, 2, 3, 4, 5]
array_1d = np.array(data_1d)
print("1D Array:", array_1d)
print("Dimensions:", array_1d.ndim)
print("Shape:", array_1d.shape)
print("Size:", array_1d.size)
print("Data Type:", array_1d.dtype)
```

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Practical Exercise:

Task: Create a one-dimensional and a two-dimensional array, explore their attributes, and perform basic operations.

```
# Creating a one-dimensional NumPy
array from a list
data_1d = [1, 2, 3, 4, 5]
array_1d = np.array(data_1d)
print("1D Array:", array_1d)
print("Dimensions:", array_1d.ndim)
print("Shape:", array_1d.shape)
print("Size:", array_1d.size)
print("Data Type:", array_1d.dtype)
```

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Understanding NumPy Arrays

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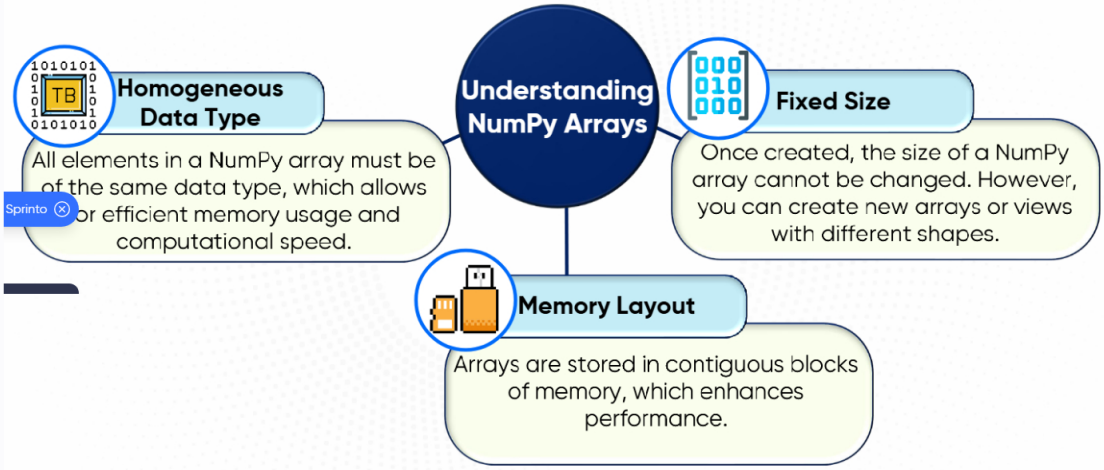

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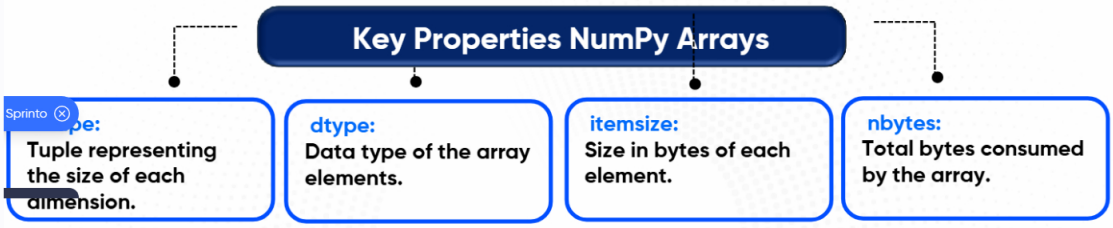


```
# Exploring array properties
print("Array Shape:", array_2d.shape)
print("Data Type:", array_2d.dtype)
print("Item Size:", array_2d.itemsize,
"bytes")
print("Total Size:", array_2d.nbytes,
"bytes")
```

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Creating NumPy Arrays

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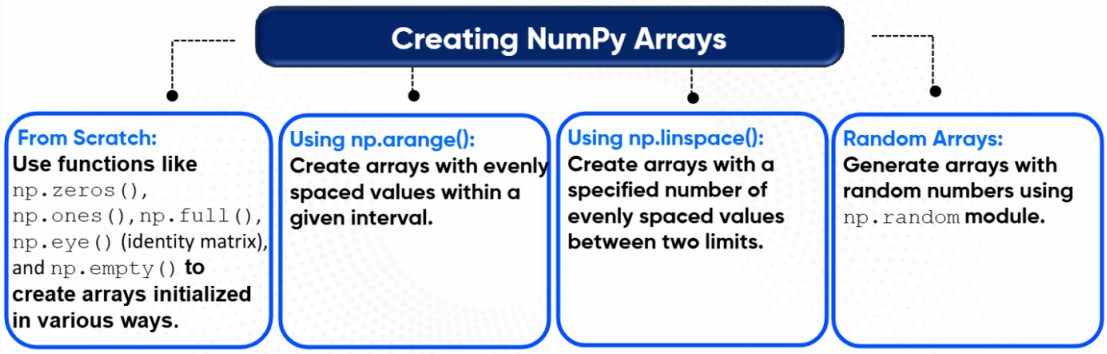

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```
# Creating arrays with different functions
zeros_array = np.zeros((2, 3))
ones_array = np.ones((2, 3))
full_array = np.full((2, 3), 7)
identity_matrix = np.eye(3)
empty_array = np.empty((2, 3))

sequence_array = np.arange(0, 10, 2)  # Start, Stop, Step
linspace_array = np.linspace(0, 1, 5)  # Start, Stop, Number of samples
```


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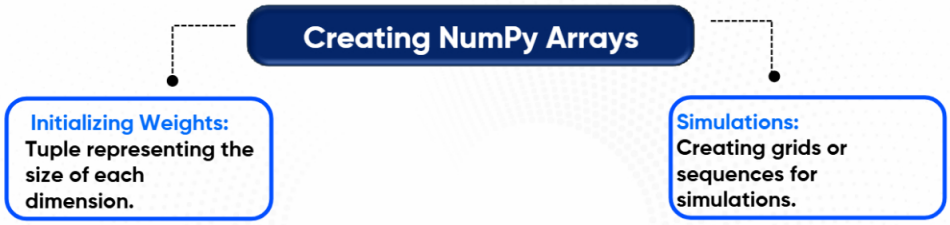


```
print("Zeros Array:\n", zeros_array)
print("\nOnes Array:\n", ones_array)
print("\nFull Array (7s):\n", full_array)
print("\nIdentity Matrix:\n", identity_matrix)
print("\nEmpty Array:\n", empty_array)
print("\nSequence Array:", sequence_array)
print("\nLinspace Array:", linspace_array)
```


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Creating NumPy Arrays from Files

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Creating NumPy Arrays from Files

Loading Data:
Use functions like `np.loadtxt()`, or `np.load()` to read data from text files or binary files.

Data Formats:
NumPy can read and write arrays to disk in various formats, including text, CSV, and its own binary .npy format.

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Example Use Case

- Loading CSV Data:

```
# Assuming 'data.csv' contains numerical data
data = np.loadtxt('data.csv', delimiter=',')
print("Loaded Data:\n", data)
```

- Note: For demonstration purposes, you can generate sample data and save it to a file, then load it.

```
# Generating sample data and saving to a file
sample_data = np.random.rand(5, 3)
np.savetxt('sample_data.csv', sample_data, delimiter=',', fmt='%.2f')

# Loading the data back
loaded_data = np.loadtxt('sample_data.csv', delimiter=',')
print("Loaded Data from CSV:\n", loaded_data)
```

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Arrays Manipulation

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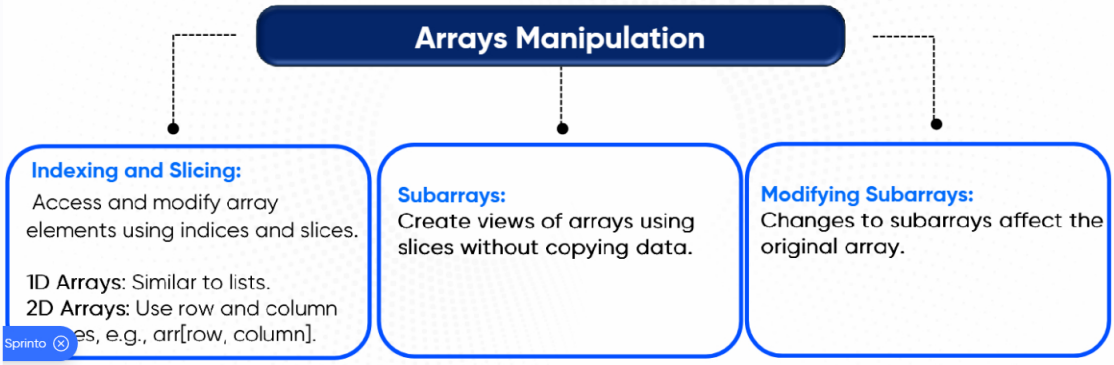

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Practical Exercise

- Task: Slice and modify elements in arrays, and observe how it affects the original array.

```
arr = np.array([10, 20, 30, 40, 50])
print("Original Array:", arr)

# Indexing
print("Element at index 1:", arr[1])

# Slicing
("Slice from index 1 to 3:", arr[1:4])

# Modifying a slice
arr_slice = arr[1:4]
arr_slice[0] = 25
print("\nModified Slice:", arr_slice)
print("Array After Slice Modification:", arr)
```

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Practical Exercise

- Task: Slice and modify elements in arrays, and observe how it affects the original array.

```
arr_slice = arr[1:4]
arr_slice[0] = 25
print("\nModified Slice:", arr_slice)
print("Array After Slice Modification:", arr)
```

```
# Concatenation
arr2 = np.array([60, 70])
concatenated_arr = np.concatenate((arr, arr2))
print("\nConcatenated Array:", concatenated_arr)
```

• **Note:** Modifying `arr_slice` affects `arr` because slices are views, not copies.

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Arrays Math Operations

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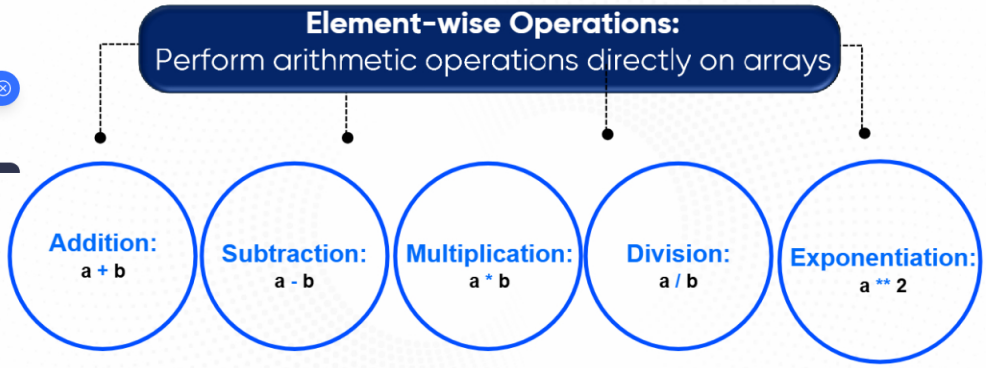

Broadcasting: NumPy can perform operations on arrays of different shapes (e.g., scalar and array).

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Practical Use Case

• **Data Normalization:** Apply mathematical transformations across datasets.

```
a = np.array([1, 2, 3])
b = np.array([4, 5, 6])

# Arithmetic operations
print("Addition:", a + b)
print("Subtraction:", a - b)
print("Multiplication:", a * b)
print("Division:", a / b)
```

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Practical Use Case

- **Data Normalization:** Apply mathematical transformations across datasets.

```
a = np.array([1, 2, 3])
b = np.array([4, 5, 6])

# Scalar operations
print("\nScalar Addition:", a + 10)
print("Scalar Multiplication:", a * 3)

# Broadcasting Example
c = np.array([[1], [2], [3]])
d = np.array([4, 5, 6])
print("\nBroadcasting Multiplication:\n", c * d)
```

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Arrays Boolean Indexing

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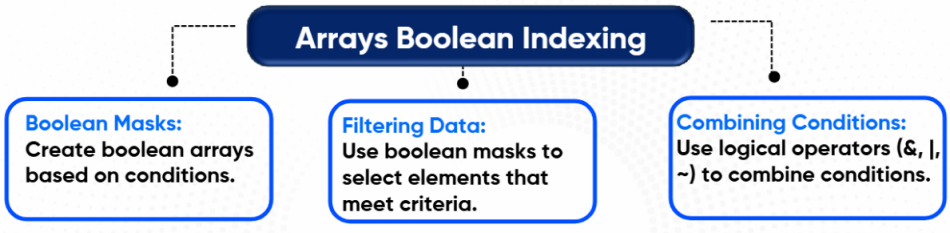

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Practical Use Case

- Task: Filter an array to extract elements based on multiple conditions.

```
# Boolean indexing example
a = np.array([1, 2, 3, 4, 5])
mask = (a > 2) & (a < 5)
filtered_array = a[mask]
print("Filtered Array (Elements >2 and <5):", filtered_array)

# Modifying elements based on condition
a[a > 3] = 10
print("Array After Modification:", a)
```

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Array Types and Casting

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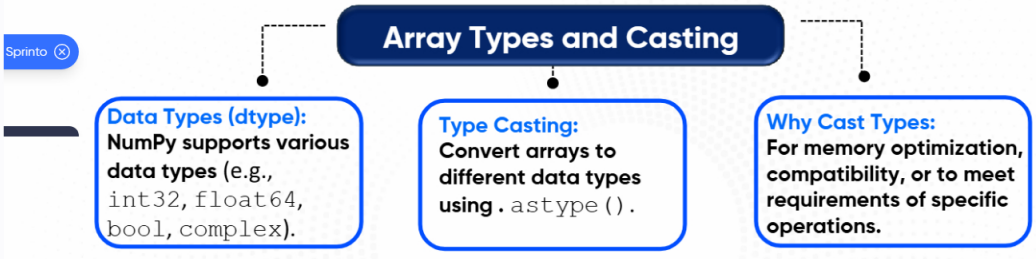

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Practical Use Case

Practical Use Case

• Task: Explore type casting and observe the effects on data.

```
float_array = np.array([1.1, 2.2, 3.3], dtype='float64')
print("Float Array:", float_array)
print("Data Type:", float_array.dtype)

# Casting to integer
int_array = float_array.astype('int32')
print("Casted to Integer:", int_array)
print("Data Type:", int_array.dtype)

# Casting to boolean
bool_array = np.array([0, 1, 2, 0], dtype='int32')
bool_array = bool_array.astype('bool')
print("Casted to Boolean:", bool_array)
print("Data Type:", bool_array.dtype)
```


Random Number Generation

Random Number Generation

Random Arrays:
Generate random numbers with various distributions.

- **Uniform distribution:** `np.random.rand()`
- **Normal distribution:** `np.random.randn()`
- **Integers:** `np.random.randint(low, high, size)`

Seed Setting:
For reproducibility, set the seed using `np.random.seed()`.

Practical Use Case

• Simulation: Generate random datasets for testing algorithms.

```
# Set seed for reproducibility
```

```
np.random.seed(42)

# Uniform distribution [0, 1)
random_array_uniform = np.random.rand(5)
print("Uniform Random Array:", random_array_uniform)

# Normal distribution (mean=0, std=1)
random_array_normal = np.random.randn(5)
print("Normal Random Array:", random_array_normal)

# Random integers between low (inclusive) and high (exclusive)
random_ints = np.random.randint(1, 100, size=5)
print("Random Integers:", random_ints)
```

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Matrix Operations Basics

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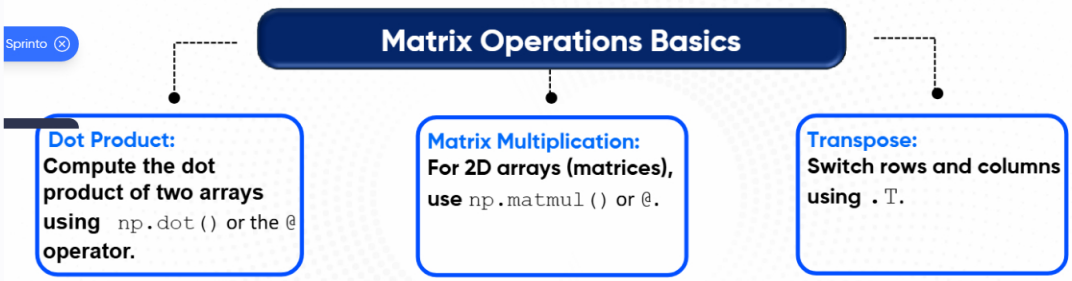

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Practical Use Case

Linear Algebra: Essential for solving equations, transformations, and more.

```
# Set seed for reproducibility
np.random.seed(42)

# Uniform distribution [0, 1)
random_array_uniform = np.random.rand(5)
```

```
print("Uniform Random Array:", random_array_uniform)

# Normal distribution (mean=0, std=1)
random_array_normal = np.random.randn(5)
print("Normal Random Array:", random_array_normal)

# Random integers between low (inclusive) and high (exclusive)
random_ints = np.random.randint(1, 100, size=5)
print("Random Integers:", random_ints)
```

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NumPy Universal Functions (ufuncs)

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NumPy Universal Functions (ufuncs)

- **Functions that operate element-wise on arrays.**
- **Examples of ufuncs:**
- **Mathematical:** `np.sqrt(), np.exp(), np.log().`
- **Benefits: Faster and more efficient than looping over array elements.**

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Practical Use Case

- Task: Apply various ufuncs to an array and analyze the results.

```
# Applying universal functions
a = np.array([1, 4, 9, 16, 25])

sqrt_array = np.sqrt(a)
exp_array = np.exp(a)
log_array = np.log(a)
```

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```
print("Original Array:", a)
print("Square Root:", sqrt_array)
print("Exponential:", exp_array)
```

```
print("Logarithm:", log_array)
```

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Solving Linear Equations

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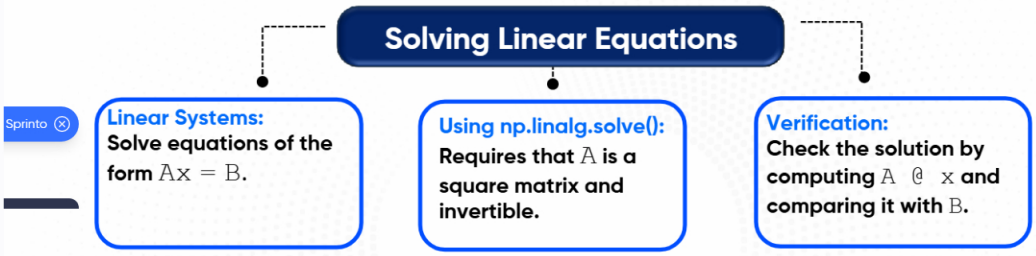

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Practical Use Case

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- **Engineering and Physics Problems:** Circuit analysis, mechanical structures, etc.

```
A = np.array([[3, 1], [1, 2]])
B = np.array([9, 8])

# Solving linear equations
solution = np.linalg.solve(A, B)
print("Solution x:", solution)

# Verification
verification = A @ solution
print("Verification (A @ x):", verification)
print("Original B:", B)
```

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Linear Algebra and Matrix Operations Basics

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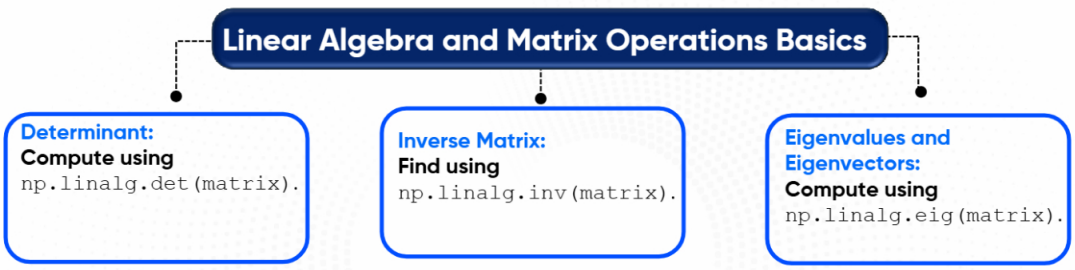

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Practical Use Case

- Task: Compute determinant, inverse, eigenvalues, and eigenvectors.

```
matrix = np.array([[2, 1], [1, 2]])

# Determinant
determinant = np.linalg.det(matrix)
print("Determinant:", determinant)

verse
inverse_matrix = np.linalg.inv(matrix)
print("\nInverse Matrix:\n", inverse_matrix)

# Eigenvalues and Eigenvectors
eigenvalues, eigenvectors = np.linalg.eig(matrix)
print("\nEigenvalues:", eigenvalues)
print("Eigenvectors:\n", eigenvectors)
```

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Reshaping Arrays

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Reshaping Arrays

Reshape:
nge the dimensions of an array using `reshape()`.

Flatten:
Convert multi-dimensional arrays to 1D using `flatten()` **or** `.ravel()`.

Reshaping Rules:
The total number of elements must remain the same.

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Practical Use Case

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k: Reshape arrays into different dimensions and understand their layout.

```
array = np.arange(12)
print("Original Array:", array)

# Reshape to 3x4
reshaped_array = array.reshape(3, 4)
print("\nReshaped to 3x4:\n", reshaped_array)

# Reshape to 2x2x3
reshaped_array_3d = array.reshape(2, 2, 3)
print("\nReshaped to 2x2x3:\n", reshaped_array_3d)

# Flatten the array
flattened_array = reshaped_array.flatten()
print("\nFlattened Array:", flattened_array)
```

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Stacking and Splitting Arrays

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Stacking and Splitting Arrays

Stacking Arrays:

Vertical Stack: `np.vstack((array1, array2))` **stacks arrays vertically (row-wise).**

Horizontal Stack: `np.hstack((array1, array2))` **stacks arrays horizontally (column-wise).**

Depth Stack: `np.dstack((array1, array2))` **stacks arrays along the third axis.**

Splitting Arrays:

Split: `np.split(array, indices_or_sections,axis=0)` **splits an array into multiple sub-arrays.**

Horizontal Split: `np.hsplit().`

Vertical Split: `np.vsplit().`

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Practical Use Case

- Task: Stack and split arrays in different ways and observe the results.

```
array1 = np.array([[1, 2], [3, 4]])
array2 = np.array([[5, 6], [7, 8]])

# Vertical Stack
v_stacked = np.vstack((array1, array2))
print("Vertical Stacked Arrays:\n", v_stacked)

# Horizontal Stack
h_stacked = np.hstack((array1, array2))
print("\nHorizontal Stacked Arrays:\n", h_stacked)

# Splitting arrays
split_array = np.hsplit(h_stacked, 2)
print("\nSplit Arrays:")
for i, arr in enumerate(split_array):
    print(f"Array {i}:\n", arr)
```

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Advanced Indexing

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Advanced Indexing

Fancy Indexing:
Use arrays of indices to
ess multiple array
ments at once.

Index Arrays:
Can be integer arrays or boolean arrays (masks).

Application:
Useful for reordering data or selecting arbitrary elements.

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Practical Use Case

- Task: Use fancy indexing to reorder elements and extract specific patterns.

```
array = np.arange(10)
indices = [2, 5, 3]
fancy_indexed_elements = array[indices]
print("Original Array:", array)
print("Indices:", indices)
print("Fancy Indexed Elements:", fancy_indexed_elements)

# Using boolean array for indexing
bool_indices = array % 2 == 0  # Select even numbers
even_elements = array[bool_indices]
print("\nBoolean Indices:", bool_indices)
print("Even Elements:", even_elements)
```

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Overiew on Pandas

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Pandas

An open-source library providing high-performance, easy-to-use tables and data analysis tools.

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Key Data Structures Pandas

Series:
One-dimensional labeled array capable of holding any data type.

DataFrame:
Two-dimensional labeled data structure with columns of potentially different types (series).

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Why Pandas?

Simplifies data manipulation, analysis, and cleaning.

Ideal for working with table shape.

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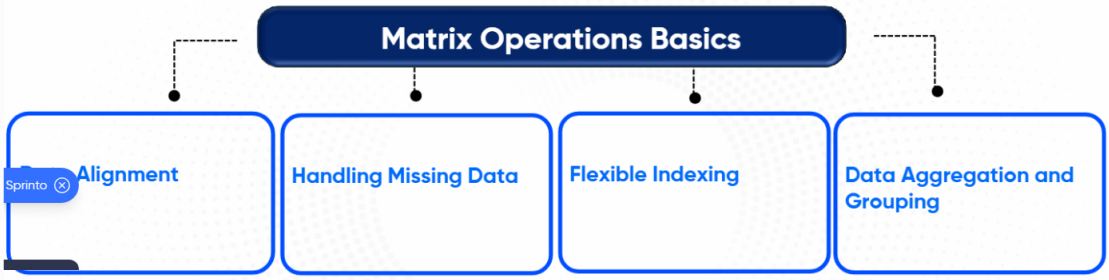

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Series and DataFrames

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Series and DataFrames

Creating a Series:

- **From a list or array:** `pd.Series(data)`
- **With a custom index:** `pd.Series(data, index=index)`

Creating a DataFrame:

- **From a dictionary of Series or arrays.**
- **From a list of dictionaries.**
- **From a NumPy array with specified column names.**

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Practical Use Case

Practical Use Case

• Task: Create Series and DataFrames from various data sources.

```
# Creating a Pandas Series with custom index
data = [10, 20, 30, 40]
index = ['a', 'b', 'c', 'd']
series = pd.Series(data, index=index)
print("Series with Custom Index:\n", series)

# Creating a DataFrame from a dictionary
data_dict = {
    'Name': ['Alice', 'Bob', 'Charlie'],
    'Age': [25, 30, 35],
    'Salary': [50000, 60000, 70000]
}
data_frame = pd.DataFrame(data_dict)
print("\nDataFrame from Dictionary:\n", data_frame)
```


Creating Series and DataFrames

Creating Series and DataFrames

• From NumPy Arrays:

```
# Creating DataFrame from NumPy arrays
array_data = np.array([[1, 2], [3, 4], [5, 6]])
columns = ['Column1', 'Column2']
df_from_array = pd.DataFrame(array_data, columns=columns)
print("DataFrame from NumPy Array:\n", df_from_array)
```


Creating Series and DataFrames

• Specifying Index and Columns:

```
# Creating DataFrame with custom index and columns
data = {
```

```
    'Column1': pd.Series([1, 2, 3], index=['a', 'b', 'c']),
    'Column2': pd.Series([4, 5, 6], index=['a', 'b', 'c'])
}
custom_df = pd.DataFrame(data)
print("\nCustom DataFrame:\n", custom_df)
```

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Importing Data

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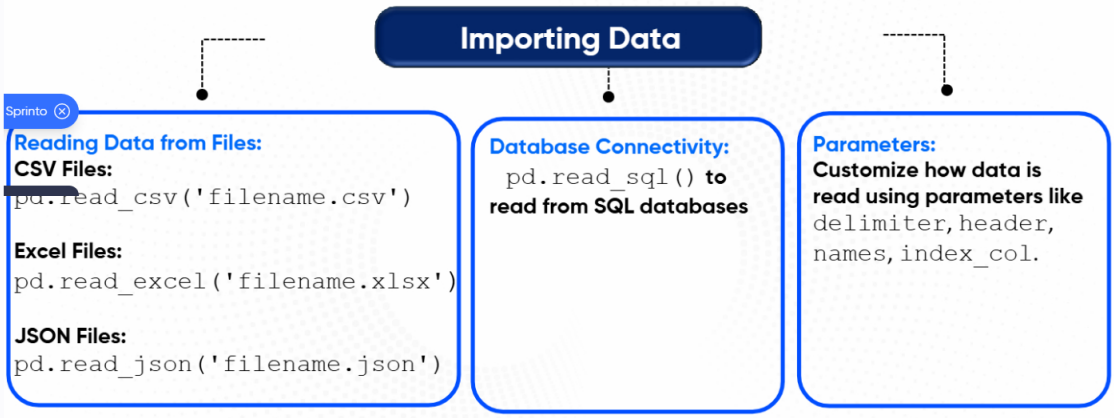

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Practical Use Case

- Load and Explore Data:

```
# Example of importing data from a CSV file
df = pd.read_csv('data.csv')
print("First 5 Rows:\n", df.head())
print("\nDataFrame Info:")
df.info()
```

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Practical Use Case

• **Note:** For practice, you can create a sample CSV file using Pandas.

```
# Create a sample DataFrame and save to CSV
sample_df = pd.DataFrame({
    'A': np.random.randint(1, 10, size=5),
    'B': np.random.rand(5),
    'C': ['foo', 'bar', 'baz', 'qux', 'quux']
})
sample_df.to_csv('sample_data.csv', index=False)
```

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Data Overview Methods

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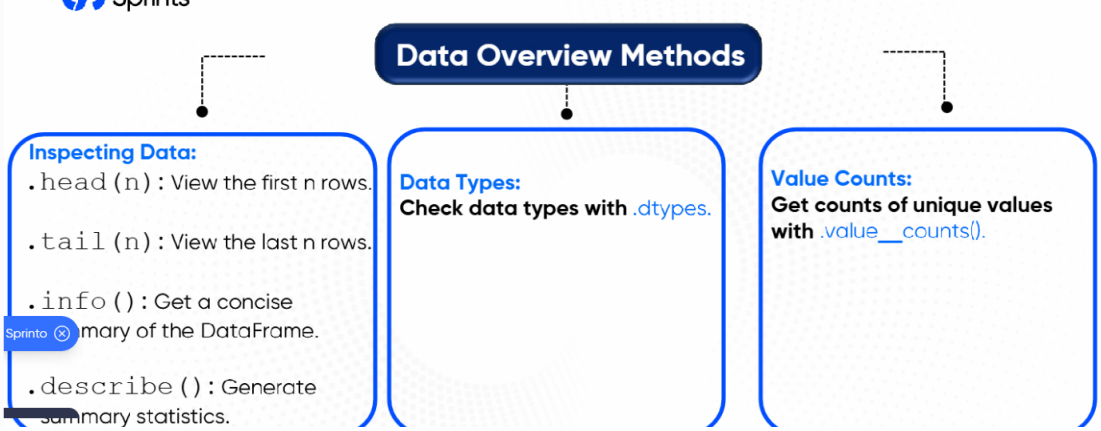

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Practical Use Case

- Task: Use various methods to get an overview of the dataset.

```
print("First 5 Rows:\n", df.head())
print("\nDataFrame Info:")
df.info()
print("\nSummary Statistics:\n", df.describe())

# Checking data types
print("\nData Types:\n", df.dtypes)

# Value counts for column 'A'
print("\nValue Counts for Column 'A':\n", df['A'].value_counts())
```

Sprints

Indexing and Selection

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Indexing and Selection

Selection by Label:

Single Column:
`df['ColumnName']` or `df.ColumnName`

Multiple Columns:
`df[['Col1', 'Col2']]`

Selection by Position:

Rows: `df[0:3]` selects rows by position.

Using `.loc[]`: Access a group of rows and columns by labels.

Using `.iloc[]`: Access by integer position.

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Practical Use Case

• Task: Practice selecting data using different methods.

```
# Selecting a single column
col_a = df['A']
print("Column A:\n", col_a)

# Selecting multiple columns
cols_ab = df[['A', 'B']]
print("\nColumns A and B:\n", cols_ab)

# Selecting rows by position
rows_1_to_3 = df[1:4]
print("\nRows 1 to 3:\n", rows_1_to_3)
```

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Practical Use Case

• Task: Practice selecting data using different methods.

```
# Using .loc[] for label-based selection
# Assuming the DataFrame has a label-based index
df.set_index('C', inplace=True)
selected_data = df.loc['foo']
print("\nData for label 'foo':\n", selected_data)

# Using .iloc[] for position-based selection
selected_data_iloc = df.iloc[2]
print("\nData at position 2:\n", selected_data_iloc)
```

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Handling Missing Data

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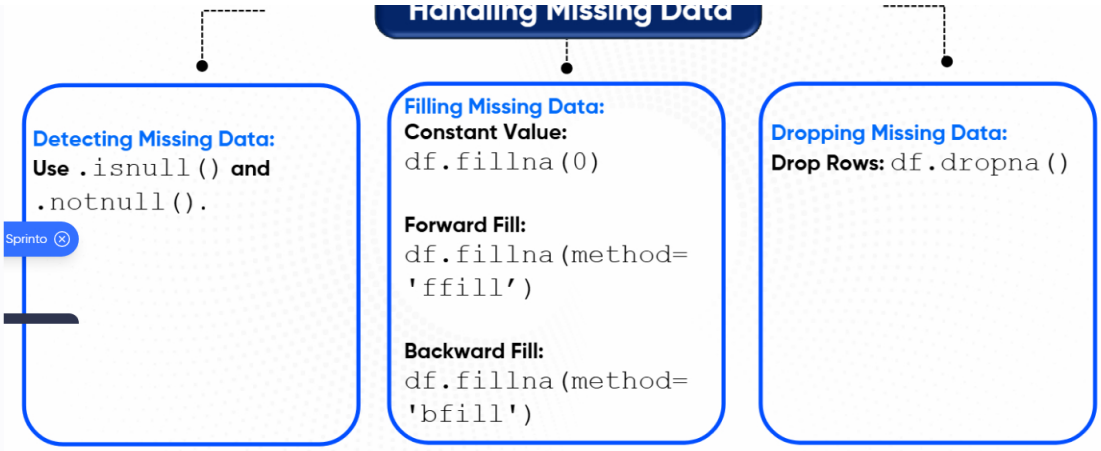

Sprints

Practical Use Case

- Task: Handle missing data in a DataFrame.

```
# Create DataFrame with missing values
data_with_nan = {
    'A': [1, np.nan, 3],
    'B': [4, 5, np.nan],
    'C': [7, 8, 9]
}
df_nan = pd.DataFrame(data_with_nan)
print("DataFrame with Missing Values:\n", df_nan)
```

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Practical Use Case

- Task: Handle missing data in a DataFrame.

```
# Detect missing values
print("\nIs Null:\n", df_nan.isnull())

# Fill missing values with 0
df_filled = df_nan.fillna(0)
print("\nDataFrame After Filling Missing Values:\n", df_filled)

# Drop rows with missing values
df_dropped = df_nan.dropna()
print("\nDataFrame After Dropping Rows with Missing Values:\n",
df_dropped)
```

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Merging and Joining DataFrames

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Merging and Joining DataFrames

`pd.merge()`:
Inner Join: Only matching keys.

Outer Join: All keys, combining data.

Left Join: All keys from left DataFrame.

Right Join: All keys from right DataFrame.

`join()`:
Convenient for joining on index.

`pd.concat()`:
Append or stack DataFrames.

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Methods to Combine DataFrames (`pd.merge()`)

1- pd.merge()

```
df1 = pd.DataFrame({'key': ['A', 'B', 'C'], 'data1': [1, 2, 3]})
df2 = pd.DataFrame({'key': ['B', 'C', 'D'], 'data2': [4, 5, 6]})

merged_df = pd.merge(df1, df2, on='key', how='outer')
print("Merged DataFrame (Outer Join):\n", merged_df)
```

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Methods to Combine DataFrames (`.join()`)

2- `.join()`

```
df1.set_index('key', inplace=True)
df2.set_index('key', inplace=True)

joined_df = df1.join(df2, how='outer')
print("\nJoined DataFrame (Outer Join):\n", joined df)
```

Sprints

Methods to Combine DataFrames (pd.concat())

3- pd.concat()

```
df_concat = pd.concat([df1, df2], axis=0)
print("\nConcatenated DataFrame (Axis=0):\n", df_concat)
```

Sprints

Differences

pd.merge():

Versatile, merges on key columns or indexes, supports different types of joins.

join():

Primarily joins on index, suitable for DataFrames with similar indexes.

pd.concat():

Concatenates along a particular axis, useful for stacking DataFrames.

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DataFrames Shape Shifting

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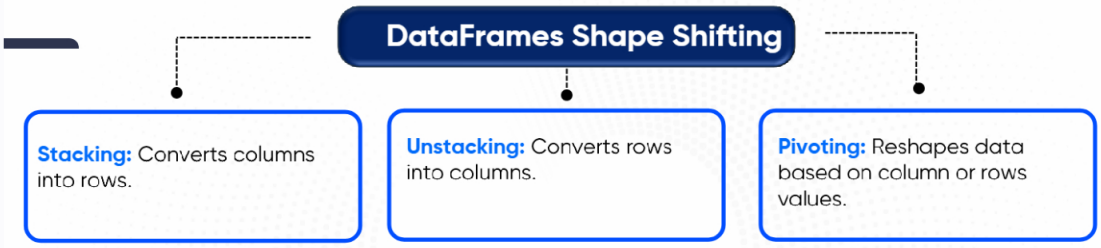

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Practical Use Case

- Task: Reshape a DataFrame using `stack()`, `unstack()`, and `pivot()`.

```
# Create a sample DataFrame
df_sample = pd.DataFrame({
    'A': ['foo', 'bar', 'foo', 'bar'],
    'B': ['one', 'one', 'two', 'three'],
    'C': np.random.randn(4),
    'D': np.random.randn(4)
})
print("Original DataFrame:\n", df_sample)

Sprinto t multi-index
df_multi = df_sample.set_index(['A', 'B'])
print("\nDataFrame with MultiIndex:\n", df_multi)
```

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Grouping Data

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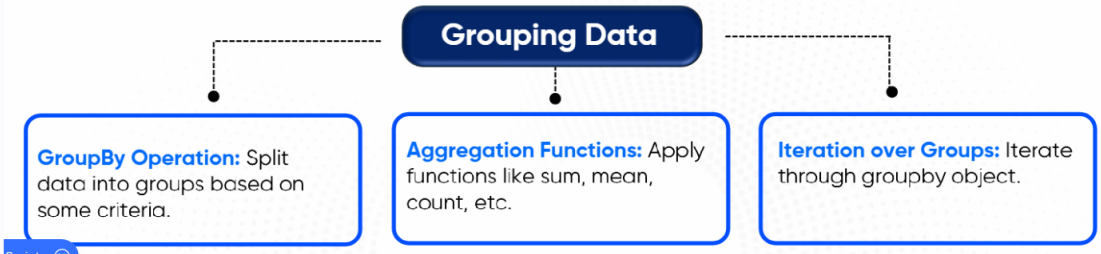

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Practical Use Case

- Task: Group data and perform aggregate operations.

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```
# Group data by column 'A'
grouped = df_sample.groupby('A')

# Calculate sum of 'C' and 'D' for each group
grouped_sum = grouped[['C', 'D']].sum()
print("Grouped Sum:\n", grouped_sum)

# Iterate over groups
for name, group in grouped:
    print(f"\nGroup: {name}")
    print(group)
```

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Aggregation Functions

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Aggregation Functions

Common Aggregations:

Sum: `df.sum()`

Mean: `df.mean()`

Median: `df.median()`

Max/Min: `df.max()`, `df.min()`

Standard Deviation: `df.std()`

Aggregation over Axis:

Specify axis with `axis` **parameter**

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Practical Use Case

- Task: Apply aggregation functions to the entire DataFrame and specific columns.

```
# Sum of all numeric columns
total_sum = df_sample[['C', 'D']].sum()
print("Total Sum:\n", total_sum)

# Mean of each group
group_mean = df_sample.groupby('A').mean()
print("\nGroup Mean:\n", group_mean)
```


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Advanced Aggregation

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Advanced Aggregation

Custom Aggregations with `.agg()`**:**

- Apply multiple functions to columns.
- Use dictionaries to specify functions per column.

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Practical Use Case

- Task: Perform advanced aggregations using `.agg()`.

```
# Apply multiple aggregations
agg_results = df_sample.groupby('A').agg({
    'C': ['sum', 'mean', 'max'],
    'D': ['min', 'std']
})
print("Advanced Aggregation Results:\n", agg_results)
```

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DataFrame Operations

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DataFrame Operations

Transposing DataFrames:

- Use `.T` to transpose, swapping rows and columns.

Sorting Data:

- Use `.sort_index()` or `.sort_values()` to sort data.

Adding and Dropping Columns:

- Add columns by assignment.
- Drop columns using `.drop()`.

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Practical Use Case

- Task: Perform various operations on a DataFrame.

```
# Transpose
transposed_df = time_series_df.T
print("Transposed DataFrame:\n", transposed_df)

# Sorting by index
sorted_df = time_series_df.sort_index(ascending=False)
print("\nDataFrame Sorted by Index (Descending):\n", sorted_df)
```

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Practical Use Case

- Task: Perform various operations on a DataFrame.

```
# Adding a new column
time_series_df['Profit'] = time_series_df['Sales'] -
time_series_df['Expenses']
print("\nDataFrame with Profit Column:\n", time_series_df)

# Dropping a column
time_series_df = time_series_df.drop('Expenses', axis=1)
print("\nDataFrame After Dropping 'Expenses' Column:\n",
time_series_df)
```

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Basic Visualization with Pandas

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Basic Visualization with Pandas

Plotting Methods:

Line Plot: `df.plot.line()`

Bar Plot: `df.plot.bar()`

Histogram: `df.plot.hist()`

Scatter Plot: `df.max(),df.min()`

Customization:

Use parameters like `title, xlabel, ylabel, figsize.`

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Practical Use Case

- Task: Create various plots to visualize data.

```
rt matplotlib.pyplot as plt

# Line Plot
time_series_df.plot(y='Sales', kind='line', title='Sales Over Time')
plt.xlabel('Date')
plt.ylabel('Sales')
plt.show()

# Bar Plot
time_series_df.plot(y='Profit', kind='bar', title='Profit Over Time')
plt.xlabel('Date')
plt.ylabel('Profit')
plt.show()
```

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Time Series Basics

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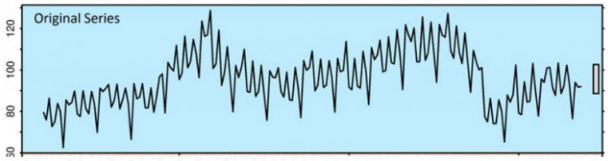
Time Series Analysis

Is a statistical technique that deals with time-ordered data points.

It involves methods for analyzing time series data to extract meaningful statistics and characteristics.



Stock Exchange | Temperatures | Sales | Call Center

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Why is it Important?

- Forecasting future values
- Understanding past behavior
- Identifying trends and seasonality
- Anomaly detection

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Example Application

Finance
Stock prices, exchange rates

Economics
GDP growth, unemployment rates

Weather
Temperature, rainfall predictions

Business
Sales forecasting, demand prediction

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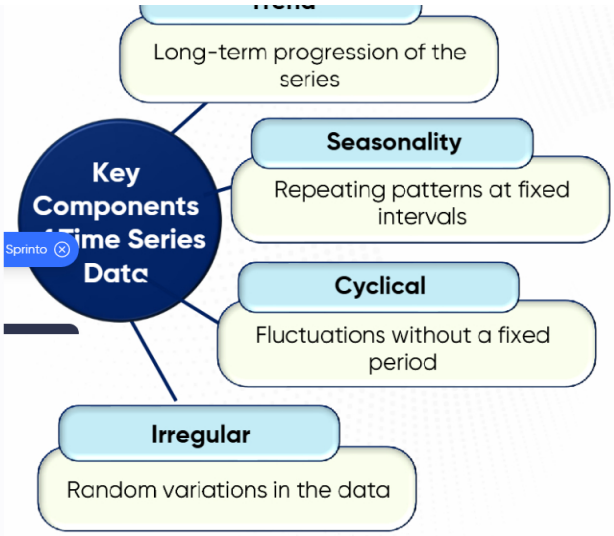
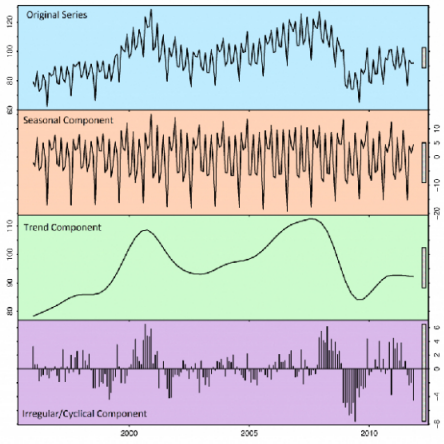
Trend





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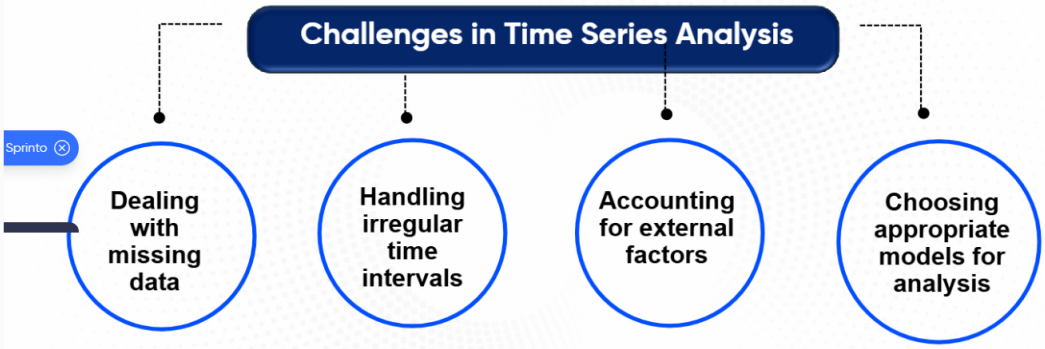

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Practical Use Case

- Task: Create and manipulate time series data.

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```
# Create date range
dates = pd.date_range('2024-01-01', periods=10, freq='D')
time_series_df = pd.DataFrame({
    'Sales': np.random.randint(100, 200, size=10),
    'Expenses': np.random.randint(50, 100, size=10)
}, index=dates)
print("Time Series DataFrame:\n", time_series_df)

# Access data by date
print("\nData on 2024-01-05:\n", time_series_df.loc['2024-01-05'])
```

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Time Series Analysis

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Time Series Analysis

Resampling Data:
Aggregate data over a new time frequency using `.resample()`.

Rolling Statistics:
Compute rolling averages or other statistics using `.rolling(window)`.

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Practical Use Case

- Task: Resample and compute rolling averages.

```
# Resample to weekly frequency and sum
weekly_sales = time_series_df['Sales'].resample('W').sum()
print("Weekly Sales:\n", weekly_sales)
# Plot weekly sales
weekly_sales.plot(kind='bar', title='Weekly Sales')
plt.xlabel('Week')
plt.ylabel('Sales')
plt.show()
```

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Practical Use Case

- Task: Resample and compute rolling averages.

```
# Compute rolling mean
time_series_df['Sales_Rolling_Mean'] =
time_series_df['Sales'].rolling(window=3).mean()
print("\nDataFrame with Rolling Mean:\n", time_series_df)
# Plot rolling mean
```

```
time_series_df[['Sales', 'Sales_Rolling_Mean']].plot(title='Sales with
Rolling Mean')
plt.xlabel('Date')
plt.ylabel('Sales')
plt.show()
```

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Practical Use Case

- Task: Resample and compute rolling averages.

```
# Compute rolling mean
time_series_df['Sales_Rolling_Mean'] =
time_series_df['Sales'].rolling(window=3).mean()
print("\nDataFrame with Rolling Mean:\n", time_series_df)
# Plot rolling mean
time_series_df[['Sales', 'Sales_Rolling_Mean']].plot(title='Sales with
Rolling Mean')
plt.xlabel('Date')
plt.ylabel('Sales')
plt.show()
```

Sprints

Vectorization

Sprints

Vectorization

Avoid Loops:
Use vectorized operations for efficiency.

Practical Use Case

- Task: Compare performance of vectorized operations vs loops.

```
# Using loop
import time
large_array = np.random.rand(1000000)
start_time = time.time()
result_loop = np.zeros_like(large_array)
for i in range(len(large_array)):
    result_loop[i] = large_array[i] * 2
print("Time with loop:", time.time() - start_time)

# Using vectorized operation
start_time = time.time()
result_vectorized = large_array * 2
print("Time with vectorization:", time.time() - start_time)
```

Observation:
- Vectorization is significantly faster.

NumPy and Pandas Together

Sprints

NumPy and Pandas Together

Integrating Libraries:
Use NumPy functions within Pandas operations.

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Example:
• mathematical functions to DataFrame columns.

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Practical Use Case

• Task: Use NumPy functions in Pandas DataFrame manipulations.

```
# Create DataFrame
oyee_data = {
    'Name': ['Alice', 'Bob', 'Charlie', 'David'],
    'Age': [25, 30, 35, 28],
    'Salary': [50000, 60000, 70000, 65000]
}
employee_df = pd.DataFrame(employee_data)

# Use NumPy to calculate bonus
employee_df['Bonus'] = np.where(employee_df['Age'] > 28,
employee_df['Salary'] * 0.1, employee_df['Salary'] * 0.05)
print("Employee Data with Bonus:\n", employee_df)
```

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NumPy and Pandas for Feature Engineering

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Feature Engineering

- In machine learning, features are the inputs to our models.
- Features are individual measurable properties or characteristics of a phenomenon being observed.

Example:

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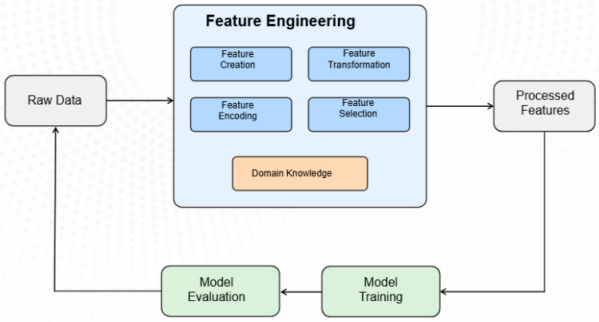
Feature Engineering

Is the process of using domain knowledge to extract features from raw data via data mining techniques. It is a crucial step in the machine learning pipeline.



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Types of Feature Engineering

Feature Creation

- Combining existing features
- Extracting information from complex data types (e.g., text, datetime)

Feature Transformation

- Scaling (normalization, standardization)
- Mathematical transformations (log, square root)

Feature Encoding

- Converting categorical variables to numerical (one-hot encoding, label encoding)

Feature Selection

- Choosing the most relevant features for the model

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NumPy and Pandas for Feature Engineering

Feature Transformation:
Use functions like `.np.log()`, `np.sqrt()`, or custom functions.

Handling Categorical Data:
Use `pd.get_dummies()` for one-hot encoding.

Scaling Data:
Apply normalization or standardization using NumPy.

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Practical Use Case

- Task: Perform feature engineering on a dataset.

```
# Log-transform the Salary
employee_df['Salary_log'] = np.log(employee_df['Salary'])
t("Employee Data with Log-transformed Salary:\n", employee_df)

# One-hot encode 'Name' column
_dummies = pd.get_dummies(employee_df['Name'], prefix='Name')
employee_df = pd.concat([employee_df, name_dummies], axis=1)
print("\nEmployee Data with One-Hot Encoded Names:\n", employee_df)

# Normalize 'Salary' column
employee_df['Salary_norm'] = (employee_df['Salary'] -
employee_df['Salary'].mean()) / employee_df['Salary'].std()
print("\nEmployee Data with Normalized Salary:\n", employee_df)
```

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Comparing Pandas with Polars

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Comparing Pandas with Polars

Pandas

- Pros:
  Easy to use, integrates well with other Python libraries.

Polars

- Pros:
  Efficient with large data.

- Cons:
  Performance degrades with large data.

- Cons:
  Steeper learning curve.

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Example

```
import polars as pl

# Creating DataFrames in Polars and Pandas
data = {'column_1': [1, 2, 3], 'column_2': [4, 5, 6]}
df_polars = pl.DataFrame(data)
df_pandas = pd.DataFrame(data)

print("Polars DataFrame:\n", df_polars)
print("\nPandas DataFrame:\n", df_pandas)
```

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Pandas vs Polars Performance Comparison

- Performance Comparison:

```
# Generate large dataset
data_large = {'column_1': np.random.rand(1000000), 'column_2':
np.random.rand(1000000)}
df_pandas_large = pd.DataFrame(data_large)
df_polars_large = pl.DataFrame(data_large)

# Pandas operation
start_time = time.time()
df_pandas_large['sum'] = df_pandas_large['column_1'] +
andas_large['column_2']
print("Pandas operation time:", time.time() - start_time)
```

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Pandas vs Polars Performance Comparison

- Performance Comparison:

```
# Polars operation
start_time = time.time()
df_polars_large = df_polars_large.with_columns([
    (pl.col('column_1') + pl.col('column_2')).alias('sum')
])
print("Polars operation time:", time.time() - start_time)
```

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Observation:

Polars can be faster with large datasets.

Sprints

Summary

Sprints

Summary

- NumPy
- Pandas
- Integration
- Key Takeaways
- Next Steps

Sprints

Summary

- NumPy:
  - Efficient array computations.
  - Multi-dimensional arrays, mathematical functions, linear algebra.
- Pandas
- Integration
- Key Takeaways
- Next Steps

Sprints

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Summary

- **NumPy**
- **Pandas**
  - Data manipulation and analysis.
  - DataFrames and Series, handling missing data, group operations.
- **Integration**
- **Key Takeaways**
- **Next Steps**

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Summary

- **NumPy**
- **Pandas**
- **Integration**
  - Use both libraries together for powerful data processing.
- **Key Takeaways**
- **Next Steps**

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Summary

- **NumPy**
- **Pandas**
- **Integration**
- **Key Takeaways:**
  - Mastering these libraries enables efficient data analysis.
  - Practical experience with real datasets enhances understanding.
- **t Steps**

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Summary

Summary

- **NumPy**
- **Pandas**
- **Integration**
- **Key Takeaways**
- **Next Steps:**
  - Practice with datasets from sources like Kaggle.
  - Explore advanced features like Pandas' time series analysis, NumPy's broadcasting rules, and performance optimization techniques.
  - Learn about other libraries like Matplotlib and Seaborn for advanced visualization.