Data Science with Python Programming

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Three-Dimensional Plotting with Matplotlib

Learning outcomes:

Three-Dimensional Plotting with Matplotlib

- **3D Line Plot**
- **3D Scatter Plot**
- **3D Contour Plot**
- **3D Surface Plot**

Three-Dimensional Plotting with Matplotlib

Matplotlib was initially designed with only two-dimensional plotting in mind. Around the time of the 1.0 release, some three-dimensional plotting utilities were built on top of Matplotlib's two-dimensional display, and the result is a convenient (if somewhat limited) set of tools for three-dimensional data visualization. Three-dimensional plots are enabled by importing the **mplot3d** toolkit, included with the main Matplotlib installation.

from mpl_toolkits import mplot3d

Three-Dimensional Plotting with Matplotlib

Once this submodule is imported, a three-dimensional axes can be created by passing the keyword projection='3d' to any of the normal axes creation routines:

```
import numpy as np
import matplotlib.pyplot as plt
fig = plt.figure()
ax = plt.axes(projection='3d')
```

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Three-Dimensional Plotting with Matplotlib

With this three-dimensional axes enabled, we can now plot a variety of three-dimensional plot types. Three-dimensional plotting is one of the functionalities that benefits immensely from viewing figures interactively rather than statically in the notebook.

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3D Line Plot

The most basic three-dimensional plot is a **3D line plot** created from sets of (x, y, z) triples. This can be created using the ax.plot3D function.

First, we have to install matplotlib to import the mplot3d toolkit. Mplot3d is a toolkit which will help for matplotlib to generate 3 axes on the graph. A three-dimensional axes can be created by passing the keyword projection='3d' to any of the normal axes creation routines.

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3D Line Plot

Example_1:**Example 1:** Let's create a basic 3D line plot using the ax.plot3D() function.

```
from mpl_toolkits import mplot3d
import numpy as np
import matplotlib.pyplot as plt
ax = plt.axes(projection='3d')
z = np.linspace(0, 1, 100)
x = z * np.sin(20 * z)
y = z * np.cos(20 * z)
ax.plot3D(x, y, z, 'gray')
ax.set_title('3D line plot')
plt.show()
```

3D Scatter Plot

A **3D Scatter Plot** is a mathematical diagram, the most basic version of three-dimensional plotting used to display the properties of data as three variables of a dataset using the Cartesian coordinates.

3D scatter plots are used to plot data points on three axes in the attempt to show the relationship between three variables. Each row in the data table is represented by a marker whose position depends on its values in the columns set on the X, Y, and Z axes.

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3D Scatter Plot

Creating 3D Scatter Plot:

To create a 3D Scatter plot, Matplotlib's **mplot3d toolkit** is used to enable three dimensional plotting. Generally 3D scatter plot is created by using ax.scatter3D() the function of the matplotlib library which accepts a data sets of X, Y and Z to create the plot while the rest of the attributes of the function are the same as that of two dimensional scatter plot.

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3D Scatter Plot

Example 1: Let's create a basic 3D scatter plot using the ax.scatter3D() function.

```
from mpl_toolkits import mplot3d
import numpy as np
import matplotlib.pyplot as plt
ax = plt.axes(projection='3d')
x =[1,2,3,4,5,6,7,8,9,10]
y =[5,6,2,3,13,4,1,2,4,8]
z =[2,3,3,3,5,7,9,11,9,10]
ax.scatter3D(x, y, z, 'green')
ax.set_title('3D Scatter plot')
plt.show()
```

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3D Contour Plot

Contour plots (sometimes called **Level Plots**) are a way to show a **three-dimensional** surface on a **two-dimensional plane**. It graphs two predictor variables X Y on the y-axis and a response variable Z as contours. These contours are sometimes called the z-slices.

A contour plot is appropriate if you want to see how value Z changes as a function of two inputs X and Y, such that Z = f(X,Y). A contour line of a function of two variables is a curve along which the function has a constant value.

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3D Contour Plot

The **ax.contour3D()** function creates three-dimensional contour plot. It requires all the input data to be in the form of two-dimensional regular grids, with the Z-data evaluated at each point. The 3d plots are enabled by importing the **mplot3d** toolkit.

Here, we will show a three-dimensional contour diagram of a three-dimensional sinusoidal function.

3D Contour Plot

Creating 3D Contour Plot:

```
from mpl_toolkits import mplot3d
import numpy as np
import matplotlib.pyplot as plt

x = np.linspace(-6, 6, 30)
y = np.linspace(-6, 6, 30)
X, Y = np.meshgrid(x, y)
Z = np.sin(np.sqrt(X ** 2 + Y ** 2))
```

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3D Contour Plot

Creating 3D Contour Plot:

```python
ax = plt.axes(projection='3d')
ax.contour3D(X, Y, Z, 50, cmap='binary')
ax.set_xlabel('x')
ax.set_ylabel('y')
ax.set_zlabel('z')
ax.set_title('3D contour')
plt.show()
```

3D Surface Plot

A **Surface Plot** is a representation of three-dimensional dataset. It describes a functional relationship between two independent variables X and Z and a designated dependent variable Y, rather than showing the individual data points. It is a companion plot of the contour plot. It is similar to the wireframe plot, but each face of the wireframe is a filled polygon. This helps to create the topology of the surface which is being visualized.

3D Surface Plot

Creating 3D Surface Plot:
The axes3d present in Matplotlib's mpl_toolkits.mplot3d toolkit provides the necessary functions used to create 3D surface plots. Surface plots are created by using the ax.plot_surface() function.

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3D Surface Plot

Creating 3D Surface Plot: Example_1

```python
from mpl_toolkits import mplot3d
import numpy as np
import matplotlib.pyplot as plt

x = np.linspace(-6, 6, 30)
y = np.linspace(-6, 6, 30)
X, Y = np.meshgrid(x, y)
Z = np.sin(np.sqrt(X ** 2 + Y ** 2))
```

3D Surface Plot

Creating 3D Surface Plot: Example_1

```
ax = plt.axes(projection='3d')
ax. plot_surface(X, Y, Z, color='green')
ax.set_xlabel('x')
ax.set_ylabel('y')
ax.set_zlabel('z')
ax.set_title('3D Surface')
plt.show()
```

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Thank you

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