# Lesson 8: Data Visualization with Matplotlib

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## Lecture Goals

This lecture introduces:

- The basics of the `matplotlib` library.
- Creating different types of plots.
- Visualizing mathematical functions.
- Reading numerical data from files.
- Customizing plots with labels, legends, and grids.

## 1 Introduction to Matplotlib

`matplotlib` is a popular Python library for creating plots and visualizations.

The most commonly used module is `matplotlib.pyplot`:

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

## 2 Line Plots: Mathematical Functions

Line plots are commonly used to visualize mathematical functions.

### Example: Plotting a Function

```
import math
import matplotlib.pyplot as plt

x = [i for i in range(-10, 11)]
y = [x_i ** 2 for x_i in x]

plt.plot(x, y)
plt.show()
```

### Using `math` Functions

```
x = [i * 0.1 for i in range(-100, 101)]
y = [math.sin(x_i) for x_i in x]

plt.plot(x, y)
plt.show()
```

## 3 Adding Labels and Titles

```
plt.plot(x, y)
plt.title("Sine Function")
plt.xlabel("x")
plt.ylabel("sin(x)")
plt.grid(True)
plt.show()
```

## 4 Multiple Plots on One Figure

```
y1 = [math.sin(x_i) for x_i in x]
y2 = [math.cos(x_i) for x_i in x]

plt.plot(x, y1, label="sin(x)")
plt.plot(x, y2, label="cos(x)")
plt.legend()
plt.show()
```

## 5 Scatter Plots

Scatter plots are useful for visualizing data points.

```
x = [1, 2, 3, 4, 5]
y = [2, 1, 3, 5, 4]

plt.scatter(x, y)
plt.show()
```

## 6 Bar Charts

Bar charts are often used to compare values.

```
names = ["Alice", "Bob", "Charlie"]
scores = [85, 90, 78]

plt.bar(names, scores)
plt.show()
```

# 7 Reading Data from a File

Consider a text file `data.txt` containing:

```
1 2
2 4
3 9
4 16
5 25
```

### Plotting File Data

```
x = []
y = []

with open("data.txt", "r") as file:
    for line in file:
        values = line.split()
        x.append(float(values[0]))
        y.append(float(values[1]))

plt.plot(x, y, marker="o")
plt.show()
```

# 8 Saving Plots to a File

```
plt.plot(x, y)
plt.savefig("plot.png")
plt.show()
```

# Summary

In this lecture, we covered:

- Creating line plots, scatter plots, and bar charts.
- Visualizing mathematical functions.
- Plotting multiple datasets.
- Reading numerical data from files.
- Customizing and saving plots.

# 9 Exercises

1. Plot the function $y = x^3$ for $x \in [-5, 5]$.
2. Plot $y = e^x$ and $y = \ln(x)$ on the same graph (for $x > 0$).
3. Create a scatter plot of 20 random points.
4. Read temperature data from a file and plot it.
5. Create a bar chart showing exam results for 5 students.
6. Challenge: Read data from a file containing $(x, y)$ pairs and plot them with:
   - a title
   - axis labels
   - grid
   - legend