Data Visualization: Subplots and Combining Visualizations

```
$ echo "Data Science Institute"
```

Overview of this slide deck, we will:

- Learn about subplot notation in matplotlib
- Put multiple visualizations on the same axes objects
- Show errors
- Adjust figure layout
- Add images to plots

Subplots

Recall: How does matplotlib work?

- A **figure** is like a container that holds a set of **axes**
- The axes is our actual plot or graph
- A figure can hold multiple axes (like subplots)
- Every visual element of our plots – colour, legends, axis titles and scales, text – is called an **artist** and belongs to an axes (not to a figure)

Setting up

- Let’s start by loading our libraries and generating some new sample data

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import scipy
import PIL
import requests

np.random.seed(613)
x1 = np.arange(50)
y1 = np.random.randint(0, 75,50)
x2 = np.array(["Luffy", "Zoro", "Nami", "Usopp", "Sanji"])
y2 = np.array([110, 180, 240, 99, 220])
```

Introducing subplots

- In past lessons, to define our figure and its one axes, we would type:

```
fig, ax = plt.subplots(figsize=(5, 3))
```

- Now we want to have two plots next to each other, so we just have to define multiple axes and their relative positions:

```
fig,(ax1, ax2) = plt.subplots(ncols=2,
                              nrows=1,
                              figsize=(7, 3))
```

Introducing subplots (cont.)

- Then we can use our new figure, with its two axes, and define the types of viz that we want to see in each

```
fig, (ax1, ax2) = plt.subplots(ncols=2,
                               nrows=1,
                               figsize=(7, 3))
ax1.scatter(x1,y1)
ax2.bar(x2,y2)
fig.show()
```

Activity: Customizing our plots

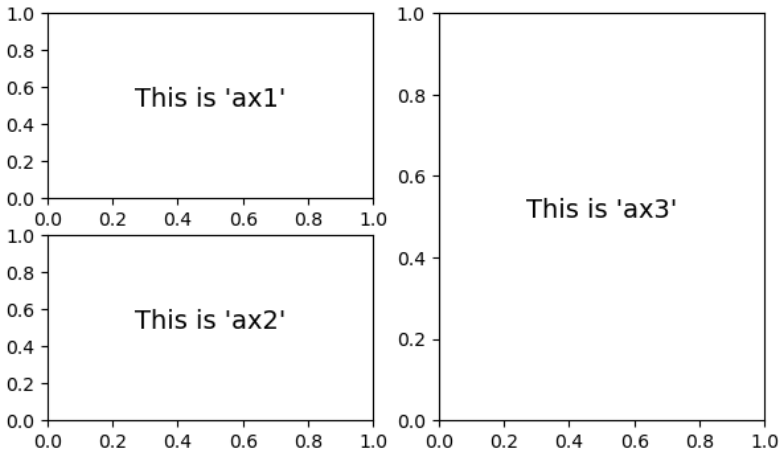
- Refer to past slides and class activities to customize the subplots we just made
- Think about adding titles or annotations, or modifying colour, marker type, and fonts – differently for each subplot
- **Share your resulting images in the chat!**

Subplots without a grid arrangement?

- We can also arrange the subplots within our figure by using **plt.subplot_mosaic()**
- Each axes in our subplot_mosaic() function has a ‘label’

```
fig, someaxes = plt.subplot_mosaic([['ax1', 'ax3'],
                                    ['ax2', 'ax3']],
                                    figsize=(7, 4))
for label, ax in someaxes.items():
ax.text(0.5, 0.5, f'This is {label!r}',
        fontsize=14,
        ha = 'center',
        transform=ax.transAxes)
```

Subplots without a grid arrangement?




```
fig, someaxes = plt.subplot_mosaic([['ax1', 'ax3'],
                                    ['ax2', 'ax3']],
                                    figsize=(7, 4))
for label, ax in someaxes.items():
ax.text(0.5, 0.5, f'This is {label!r}',
        fontsize=14,
        ha = 'center',
        transform=ax.transAxes)
```

Subplots without a grid arrangement - Data

- Once we've made our mosaic, we can add data to each of our subplots the same way we did before! Just reference each axes label in our someaxes list:

```
fig, someaxes = plt.subplot_mosaic([['ax1', 'ax3'],
                                    ['ax2', 'ax3']],
                                    figsize=(7, 4))
someaxes["ax1"].scatter(x1,y1)
someaxes["ax2"].bar(x2,y2)
someaxes["ax3"].plot(x1,y1)
plt.show()
```

Feedback!

Agenda for today

- Finish working through slide deck #6: Subplots and combining visualizations
- Go through slide deck #7: Accessible data visualization
- Discuss assignment 3

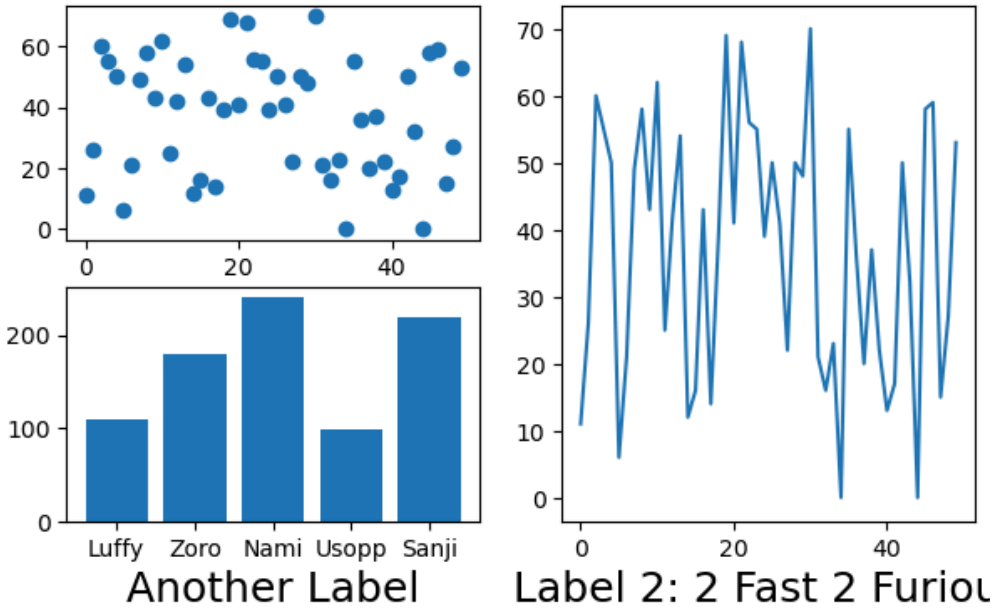
Review feedback from last session

Modify figure layout

Layouts

- Let's try adding some very large x axis titles to our previous plot

```
fig, someaxes = plt.subplot_mosaic([['ax1', 'ax3'],
                                    ['ax2', 'ax3']],
                                    figsize=(7, 4))
someaxes["ax1"].scatter(x1,y1)
someaxes["ax2"].bar(x2,y2)
someaxes["ax3"].plot(x1,y1)
someaxes["ax1"].set_xlabel('A Big Label',fontsize=18)
someaxes["ax2"].set_xlabel('Another Label',fontsize=18)
someaxes["ax3"].set_xlabel('Label 2: 2 Fast 2 Furious',fontsize=18 )

plt.show()
```



Layouts

- The axis title for our scatter plot doesn't appear, and the axis title for our line plot is cut off!

Layouts

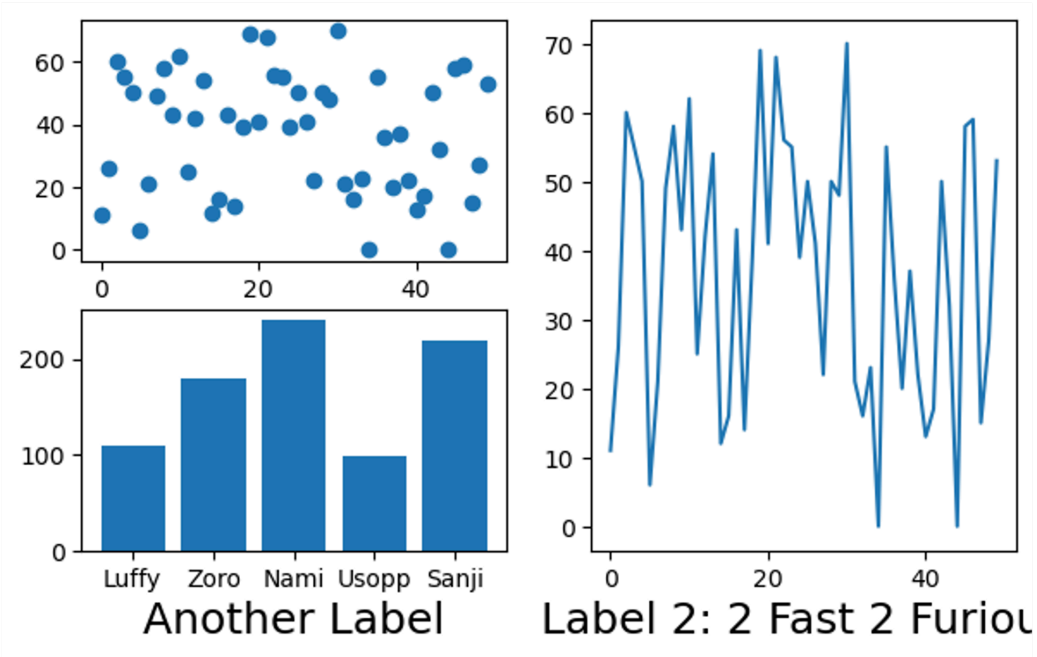
- We can use layouts to make sure that our subplots fit neatly in our figure area
- There are two main kinds of layout we consider:
  - **Tight layout** adjusts subplots so tick labels, axis labels, and titles don't overlap or leave the figure area
  - **Constrained layout** works similarly except it also fits things like legends or colorbars

Layouts

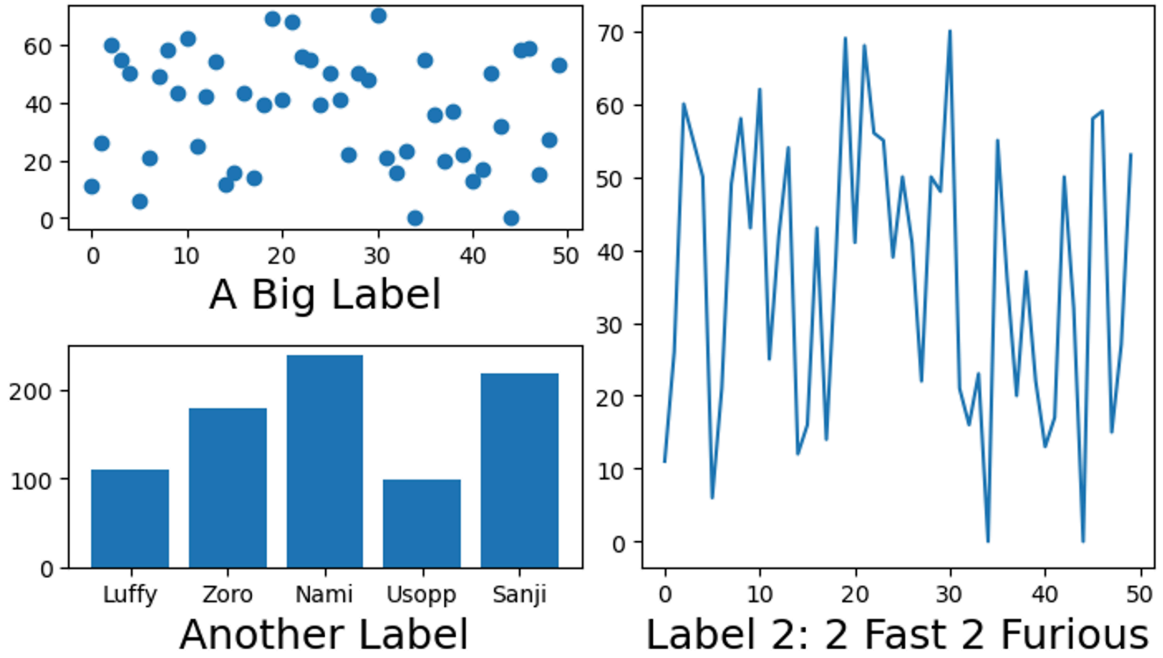
- First let's see how a constrained layout changes our plot:

```
fig, someaxes = plt.subplot_mosaic([['ax1', 'ax3'],
                                    ['ax2', 'ax3']],
                                    figsize=(7, 4),
                                    layout = "constrained")
someaxes["ax1"].scatter(x1,y1)
someaxes["ax2"].bar(x2,y2)
someaxes["ax3"].plot(x1,y1)
someaxes["ax1"].set_xlabel('A Big Label', fontsize=18)
someaxes["ax2"].set_xlabel('Another Label', fontsize=18)
someaxes["ax3"].set_xlabel('Label 2: 2 Fast 2 Furious', fontsize=18)

plt.show()
```

Layouts Comparison



No layout specified



Constrained layout

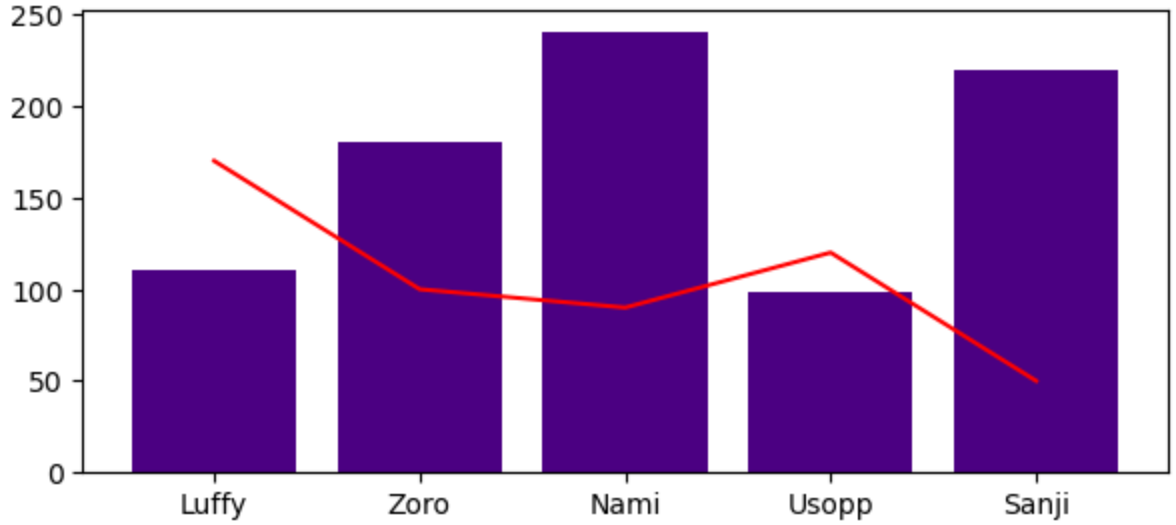
Multiple viz on one axes

Multiple viz on one axes object

- Super easy: just call multiple plot methods on the same axes

```
# first make our sample data
x = np.array(["Luffy", "Zoro", "Nami", "Usopp", "Sanji"])
y1 = np.array([110, 180, 240, 99, 220])
y2 = np.array([170, 100, 90, 120, 50])

# define our figure and axes (just one this time)
fig, ax = plt.subplots(figsize=(7, 3))

# now call both bar and plot elements to the same axes (ax)
ax.bar(x, y1,
color = "indigo")
ax.plot(x, y2,
color = "red")
```

Multiple viz on one axes object



Annotations, shapes, etc. can be added as usual!

Add error information

- First, calculate standard deviation of our data

```
y2_sd = np.std(y2)
```

- Then plot our line as before

```
fig, ax = plt.subplots(figsize=(7, 3))
ax.plot(x, y2, color = "red")
```

Add error information

- Then use **errorbar()** to add in our error line (standard deviation in this case, but could be whatever value you calculated)
    - yerr specifies that we're plotting vertical error bars
    - fmt makes sure we're not plotting the actual data points, only the error

```
ax.errorbar(x, #our x values
        y2, #our y values
        yerr = y2_sd,
        fmt = "none")
```

Customizing errorbar appearance

```
fig, ax = plt.subplots(figsize=(7, 3))
ax.plot(x, y2,
        color = "red")
ax.errorbar(x,
        y2,
        yerr = y2_sd,
        fmt = "none",
        ecolor= "indigo",
        elinewidth= 4,
        capsize = 6,
        capthick= 4 )
```

Errorevery

- If we don’t want to see error bars for every single point, we can specify intervals using **errorevery**

```
ax.errorbar(x,
        y2,
        yerr = y2_sd,
        fmt = "none",
        ecolor = "indigo",
        elinewidth = 4,
        capsize = 6,
        capthick = 4,
        errorevery= 2 )
```

Add images to plots


THIS IS TOO MUCH

Using images from the internet

- First let's load our libraries

```
from PIL import Image # to open images
import requests # to get images from URLs
from io import BytesIO # to store images
```

- Then get our image from the internet

```
response = requests.get('https://upload.wikimedia.org/wikipedia/en/c/cb/Monkey_D_Luffy.png')
image_file = BytesIO(response.content)
image = Image.open(image_file)
```

Adding an image to a plot

- Now make a basic line plot (reusing our data)

```
fig, ax = plt.subplots(figsize=(7, 3))
ax.plot(x, y2, color = "red")
```

- Then overlay a new axis (‘ax_image’) on our figure (on top of ‘ax’) to act as a container for our image

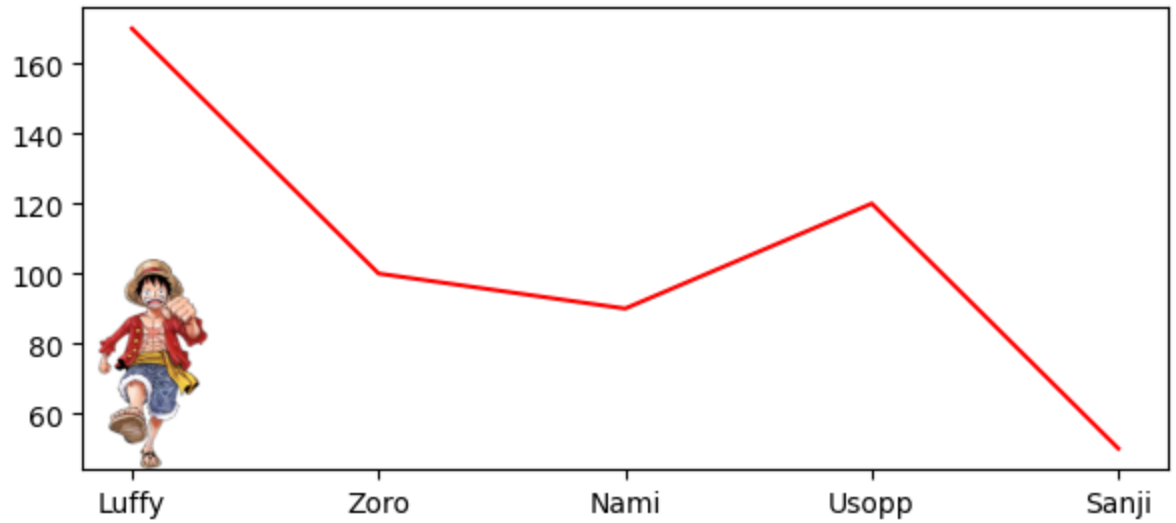
```
ax_image = fig.add_axes([0.1, # x coordinate (ON FIGURE, NOT AXES)
                         0.11, # y coordinate (ON FIGURE, NOT AXES)
                         0.15, # image width
                         0.35] # image height)
```

Adding an image to a plot

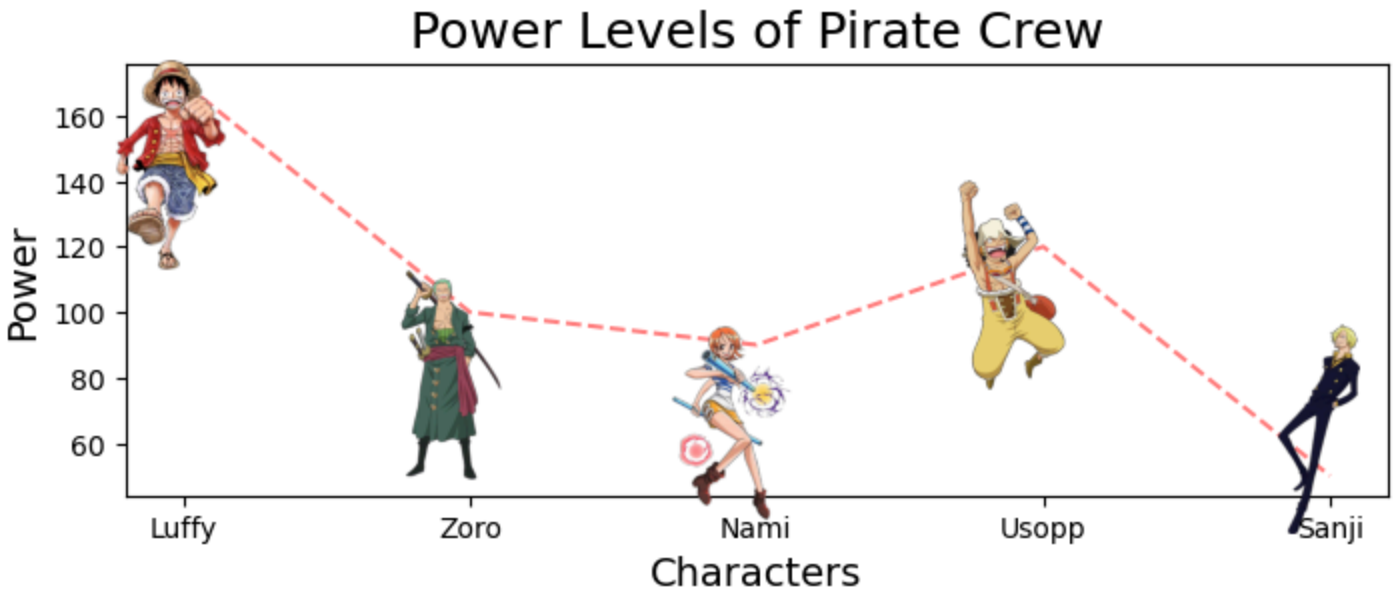
- Then add imshow() to add the image we prepared before

```
fig, ax = plt.subplots(figsize=(7, 3))
ax.plot(x, y2,
        color = "red")

ax_image = fig.add_axes([0.1, 0.11, 0.15, 0.35])

ax_image.imshow(image)
ax_image.axis('off’)
plt.show()
```

Adding images to our plots



What can we make?



Saving our visualizations

- First, let's define where we want to save our visualization

```
path = 'C:/Users/...'
# can be full path or relative path
filename = '/fig1a.png'
```

- Then save the visualization

```
plt.savefig(path+filename, dpi=300)
# note that path shouldn't end with / since filename starts with it
```

Next…

- Accessible data visualization, including
  - Colour
  - Text
  - Image description and alt. text