Creating Data Visualizations with Python

November 2024

Housekeeping

- In case of technical problems:
  - Something wrong on my end (e.g. power outage), I will send you an email.
  - Something wrong on your end, please send me a text message. 508-769-6446
  - jcodygroup@gmail.com
- For the session
  - I will try to give you an opportunity to stand and stretch every hour.
  - We will take at least one 15-minute break near the halfway point of the morning and afternoon.

About me

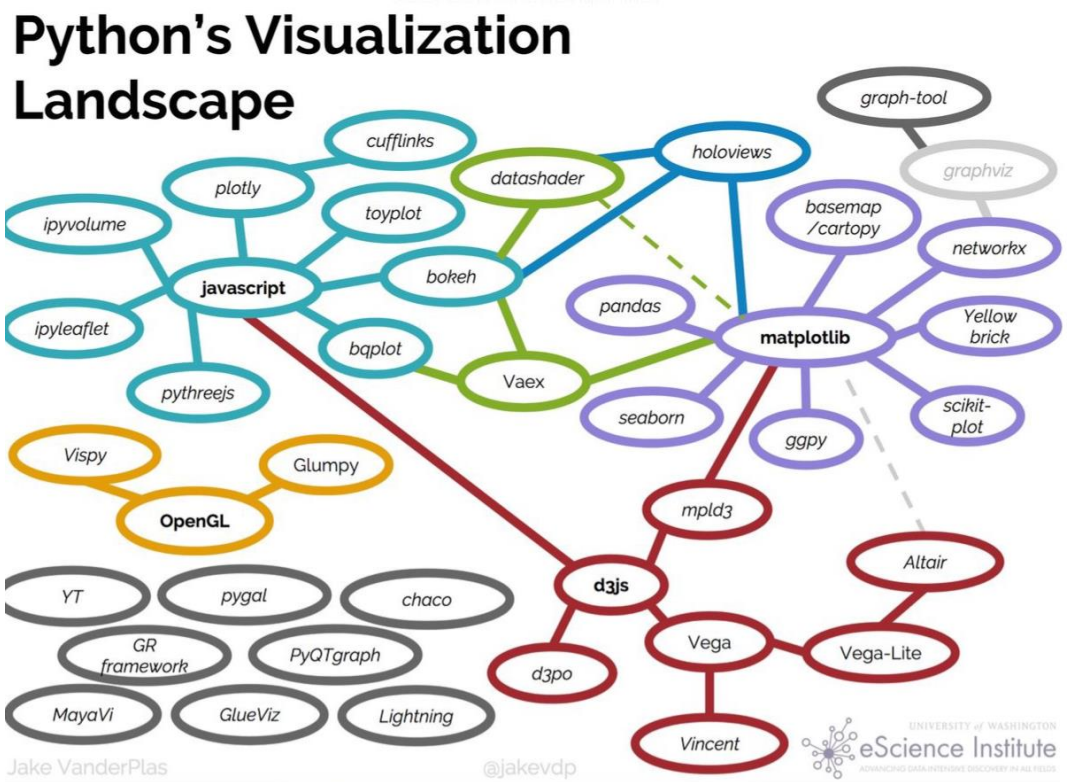
- **Experience:**
  - 25+ years consulting and training experience
  - Extensive work with “big data” and analytics
  - 15 years working with various data visualization tools
- **Education**
  - Ed. M., Technology, Innovation & Education, Harvard University
  - PhD Candidate, Education Policy, University of Massachusetts, Amherst

Learning Objective

Knowledge, skillsets, mindsets

- Knowledge of:
  - A variety of python data visualization packages
  - The structure of visualizations
  - Package documentation
- Skillsets:
  - The ability to produce basic plots with some formatting using matplotlib & seaborn
- Mindsets:
  - Think, sketch before coding

Note: We will be focusing on plotting. We will not be doing any data manipulation to prepare for plotting.



matplotlib

Version 3.4.3

seaborn: statistical data visualization

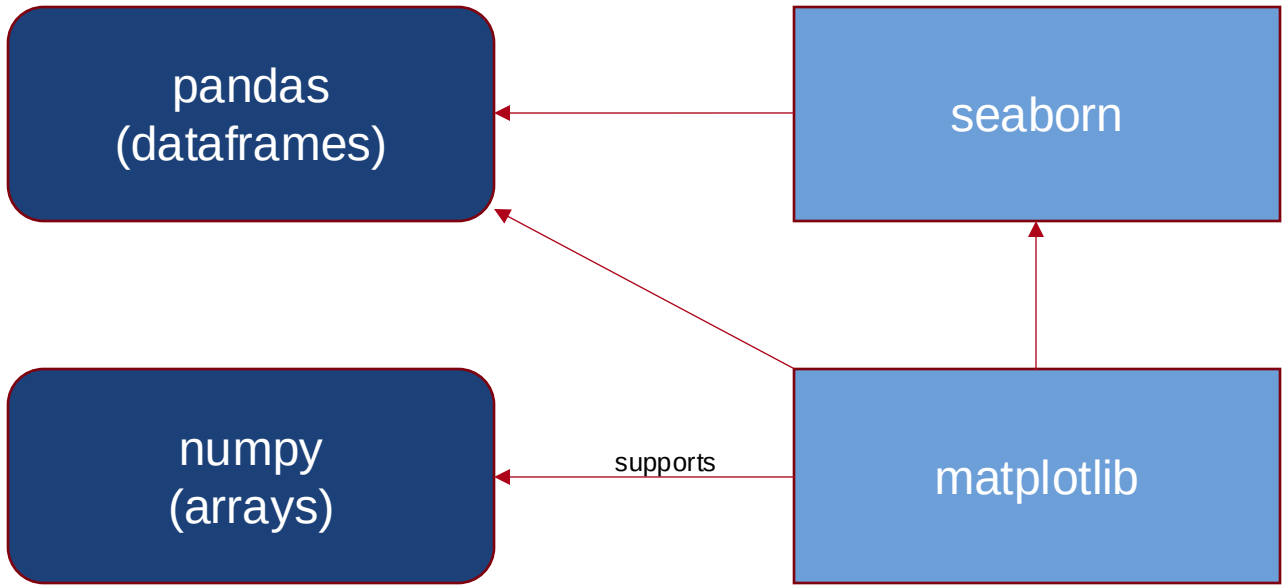
The Bokeh Visualization Library

plotnine 0.8.0 API Gallery Tutorials Site Page

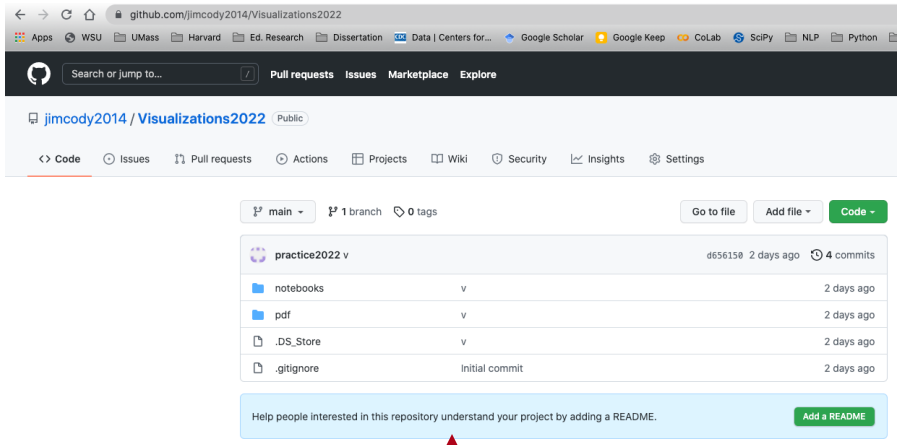
A Grammar of Graphics for Python

Altair: Declarative Visualization in Python

‘Workhorse’ data & visualization packages

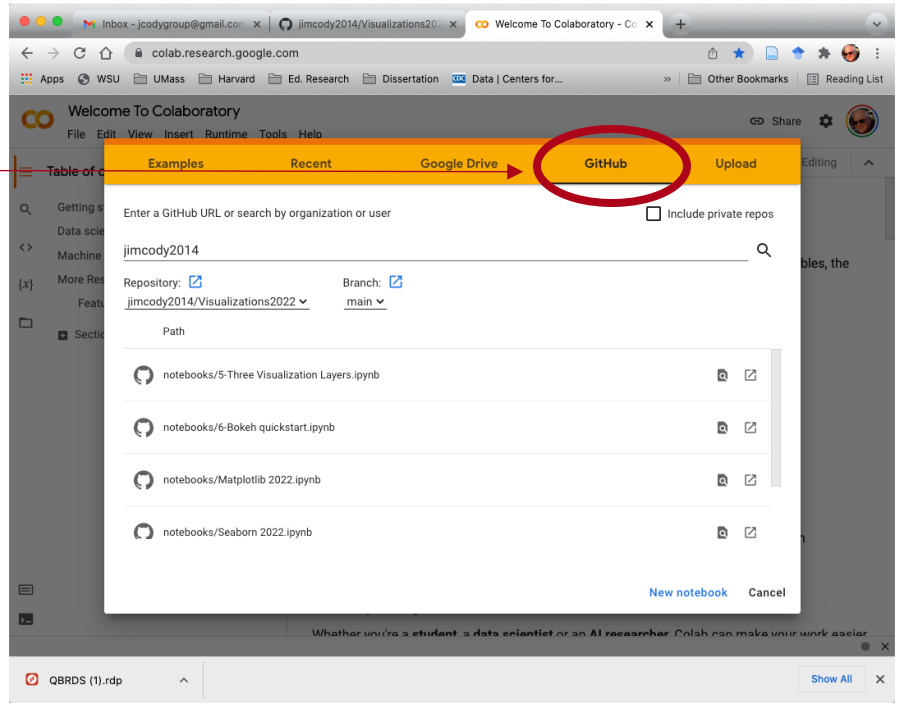


Accessing jupyter notebooks for class

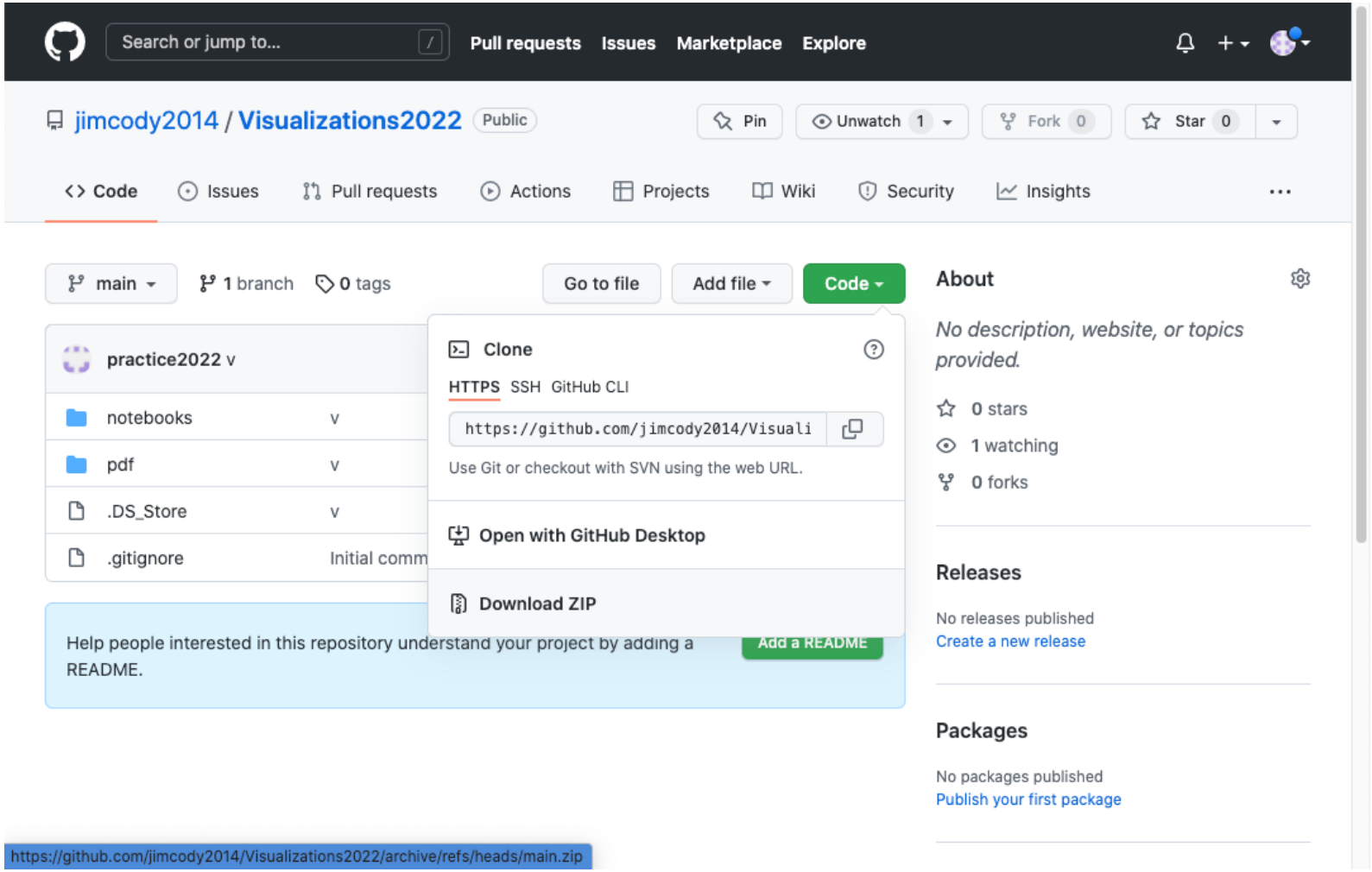


git push

Jim's Desktop



You can also download from github (this is optional!)

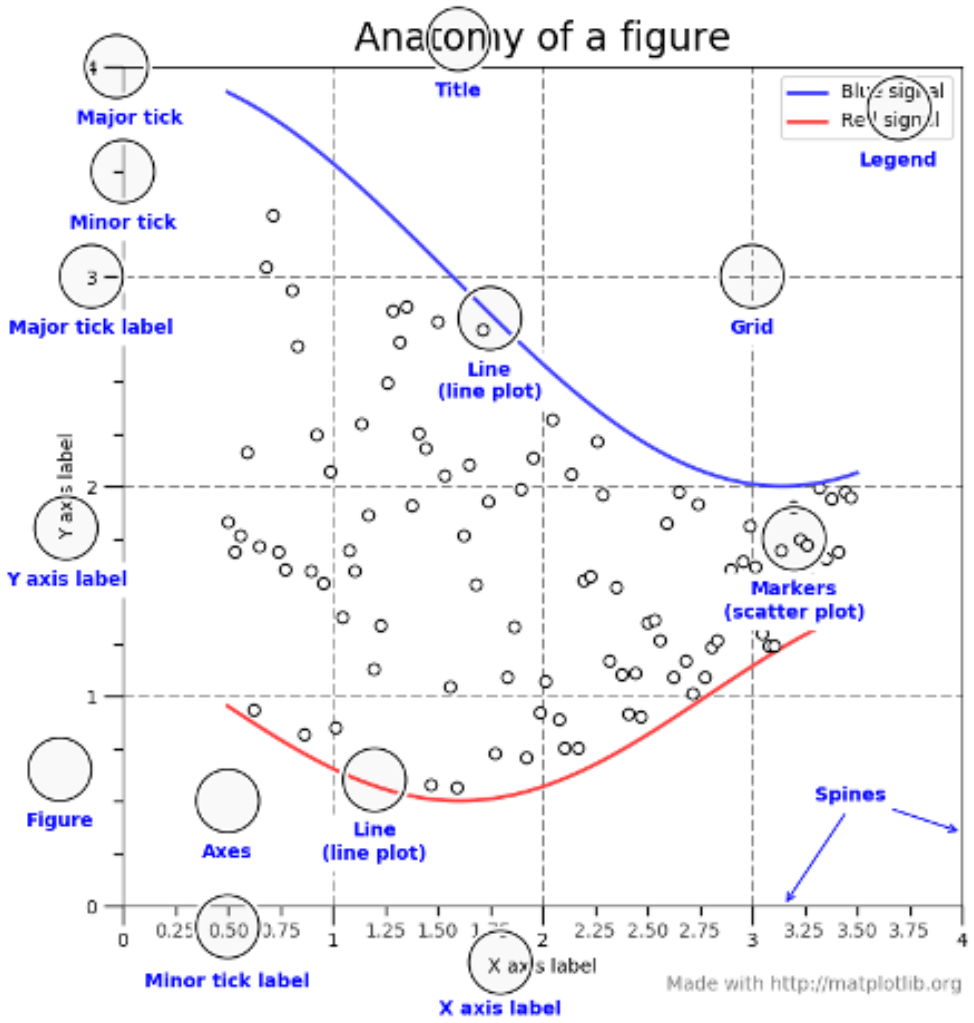


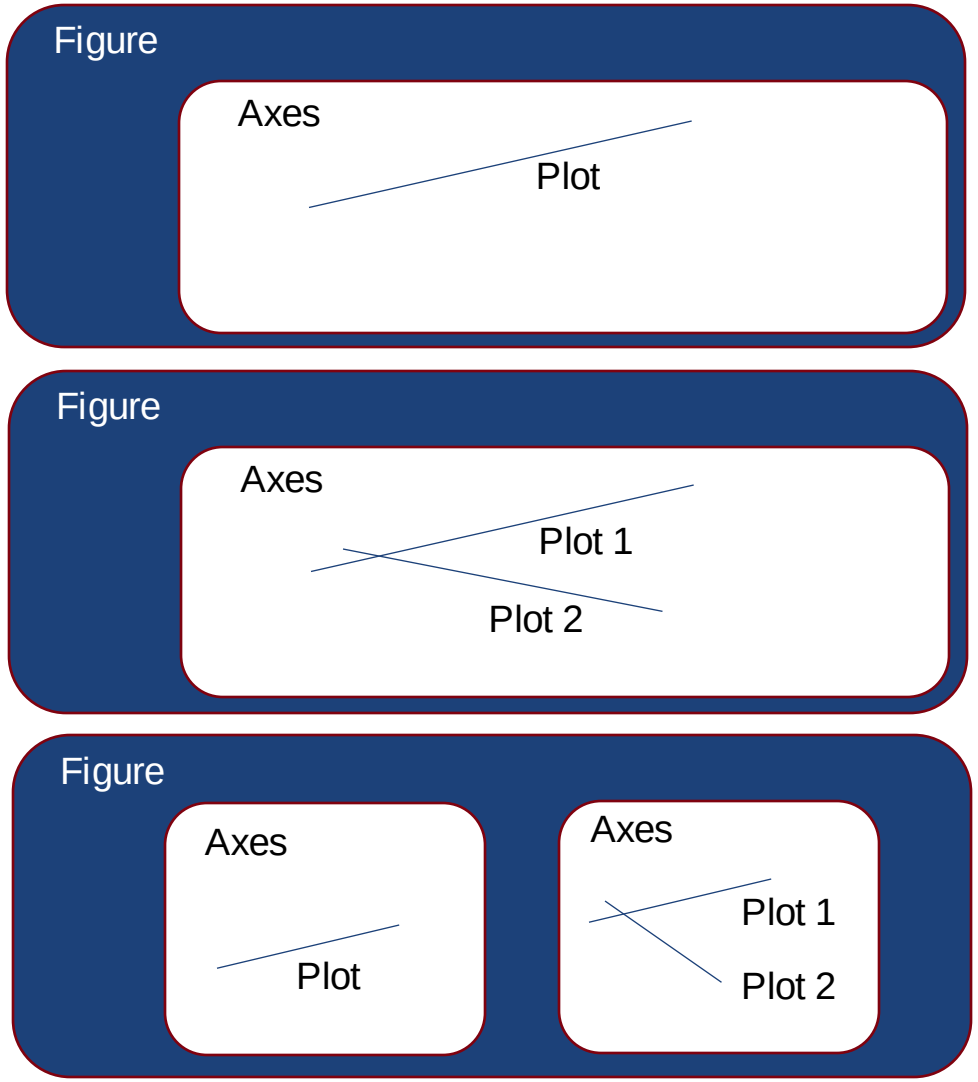
Matplotlib

Matplotlib

- Matplotlib is a popular Python package used to build plots.
- It was started as a project in the early 2000's to replicate MATLAB's plotting capability with Python.
- Matplotlib has three interfaces (ways to write code)
  - pyplot – hides the complexity of object-oriented coding.
  - object-oriented – provides access to more functions and control over the visualizations
  - pylab (not recommended for use)
- This lesson covers the pyplot and object-oriented interfaces

Two big concepts to keep in mind





Objects – modules, methods and parameters

- matplotlib.figure
  - matplotlib.figure.Figure
    - matplotlib.figure.Figure.add_axes
    - matplotlib.figure.Figure.add_subplot
    - matplotlib.figure.Figure.subplots
    - matplotlib.figure.Figure.subplot_mosaic
    - matplotlib.figure.Figure.add_gridspec
    - matplotlib.figure.Figure.get_axes
    - matplotlib.figure.Figure.axes
    - matplotlib.figure.Figure.delaxes
    - matplotlib.figure.Figure.subfigures
    - matplotlib.figure.Figure.add_subfigure

```
class matplotlib.figure.Figure(figsize=None, dpi=None, *, facecolor=None,
edgecolor=None, linewidth=0.0, frameon=None, subplotpars=None,
tight_layout=None, constrained_layout=None, layout=None, **kwargs) [source]
```

The top level container for all the plot elements.

matplotlib.figure.Figure.subplots

```
Figure.subplots(nrows=1, ncols=1, *, sharex=False, sharey=False,
squeeze=True, width_ratios=None, height_ratios=None, subplot_kw=None,
gridspec_kw=None)                                                [source]
```

Add a set of subplots to this figure.

Adding axes

fig.add_axes: for absolute positioning

```
fig = plt.figure()
ax1 = fig.add_axes([0,0,1,1])  # left, bottom, width, height
ax2 = fig.add_axes([0.15, 0.1, 0.7, 0.3])
```

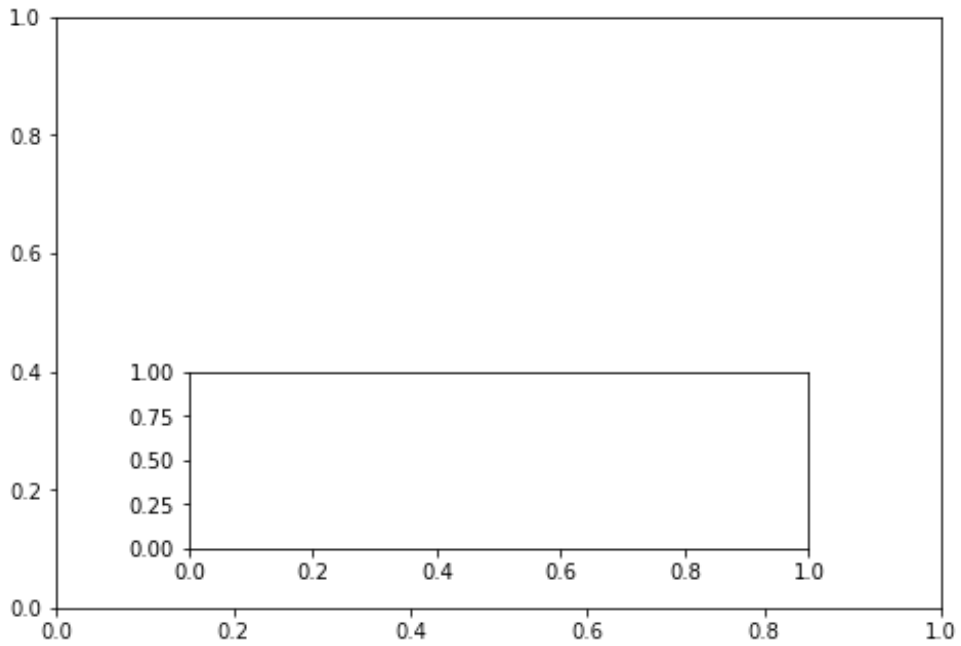


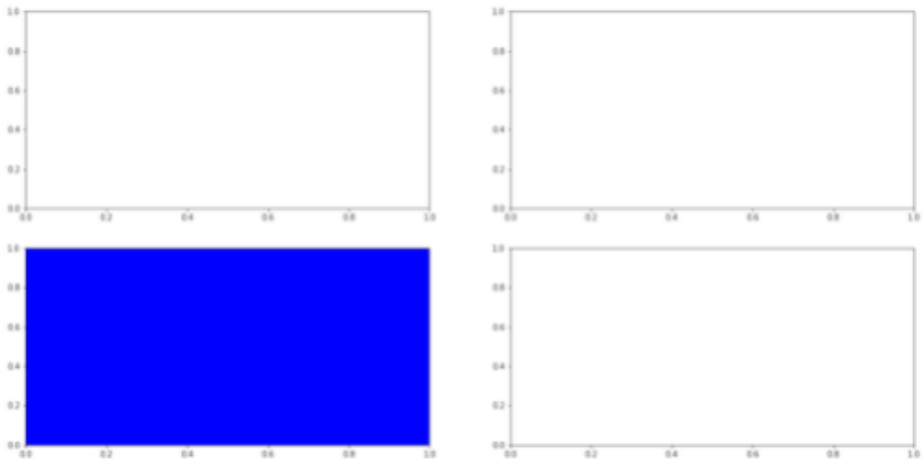
fig.add_subplot: for grid positioning

```
# Initialize the plot
fig = plt.figure(figsize=(20,10))
ax1 = fig.add_subplot(2,2,1)
ax2 = fig.add_subplot(222)
ax3 = fig.add_subplot(223)
ax4 = fig.add_subplot(224)

ax3.set_facecolor('blue')



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



Subplots using pyplot

subplot	Add an Axes to the current figure or retrieve an existing Axes.
subplot2grid	Create a subplot at a specific location inside a regular grid.
subplot_mosaic	Build a layout of Axes based on ASCII art or nested lists.
subplot_tool	Launch a subplot tool window for a figure.
subplots	Create a figure and a set of subplots.
subplots_adjust	Adjust the subplot layout parameters.

```
plt.subplot(221)

# equivalent but more general
ax1 = plt.subplot(2, 2, 1)

# add a subplot with no frame
ax2 = plt.subplot(222, frameon=False)

# add a polar subplot
plt.subplot(223, projection='polar')

# add a red subplot that shares the x-axis with ax1
plt.subplot(224, sharex=ax1, facecolor='red')

# delete ax2 from the figure
plt.delaxes(ax2)

# add ax2 to the figure again
plt.subplot(ax2)

# make the first axes "current" again
plt.subplot(221)
```

from the documentation

```
# First create some toy data:
x = np.linspace(0, 2*np.pi, 400)
y = np.sin(x**2)

# Create just a figure and only one subplot
fig, ax = plt.subplots()
ax.plot(x, y)
ax.set_title('Simple plot')

# Create two subplots and unpack the output array immediately
f, (ax1, ax2) = plt.subplots(1, 2, sharey=True)
ax1.plot(x, y)
ax1.set_title('Sharing Y axis')
ax2.scatter(x, y)

# Create four polar axes and access them through the returned array
fig, axs = plt.subplots(2, 2, subplot_kw=dict(projection="polar"))
axs[0, 0].plot(x, y)
axs[1, 1].scatter(x, y)

# Share a X axis with each column of subplots
plt.subplots(2, 2, sharex='col')

# Share a Y axis with each row of subplots
plt.subplots(2, 2, sharey='row')

# Share both X and Y axes with all subplots
plt.subplots(2, 2, sharex='all', sharey='all')

# Note that this is the same as
plt.subplots(2, 2, sharex=True, sharey=True)

# Create figure number 10 with a single subplot
# and clears it if it already exists.
fig, ax = plt.subplots(num=10, clear=True)
```

from the documentation

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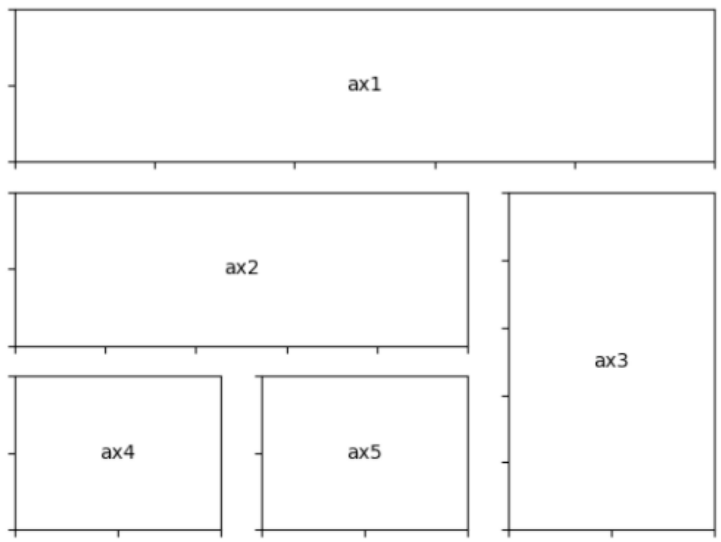


```
import matplotlib.pyplot as plt


def annotate_axes(fig):
    for i, ax in enumerate(fig.axes):
        ax.text(0.5, 0.5, "ax%d" % (i+1), va="center", ha="center")
        ax.tick_params(labelbottom=False, labelleft=False)


fig = plt.figure()
ax1 = plt.subplot2grid((3, 3), (0, 0), colspan=3)
ax2 = plt.subplot2grid((3, 3), (1, 0), colspan=2)
ax3 = plt.subplot2grid((3, 3), (1, 2), rowspan=2)
ax4 = plt.subplot2grid((3, 3), (2, 0))
ax5 = plt.subplot2grid((3, 3), (2, 1))

annotate_axes(fig)

plt.show()
```

from the documentation

Seaborn

Seaborn

- Seaborn is a library for making statistical graphics in Python.
- It builds on top of matplotlib and integrates closely with pandas data structures.
- Seaborn plotting functions operate on dataframes and arrays containing whole datasets and internally perform the necessary semantic mapping and statistical aggregation to produce informative plots.
- Its dataset-oriented, declarative API lets you focus on what the different elements of your plots mean, rather than on the details of how to draw them.

Grammar of Graphics