Plotting and Visualization

Prof. Gheith Abandah

Reference

- **Chapter 9: Plotting and Visualization**

- Wes McKinney, **Python for Data Analysis**: Data Wrangling with Pandas, NumPy, and IPython, O’Reilly Media, 2nd Edition, 2018.
  - Material: https://github.com/wesm/pypop-book

Plotting and Visualization

- **Making informative visualizations** is one of the most important tasks in data analysis.

- It may be a part of the **exploratory process**: to help identify outliers or needed data transformations, or as a way of generating ideas for models.

Outline

9.1 A Brief **matplotlib** API Primer

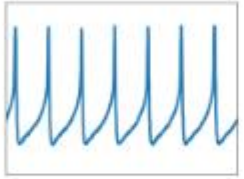
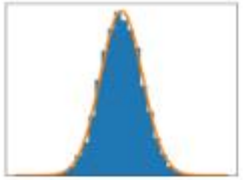
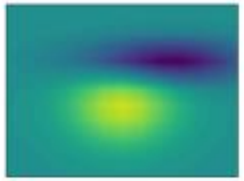
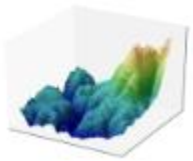
- Figures and Subplots
- Colors, Markers, and Line Styles
- Ticks and Labels
- Saving Plots to File
- matplotlib Configuration

9.2 Plotting with **pandas** and **seaborn**

- Line Plots
- Bar Plots
- Histograms and Density Plots
- Scatter or Point Plots
- Facet Grids and Categorical Data

Matplotlib: MATLAB-style Scientific Visualization

- Matplotlib is a Python **plotting library** which produces publication **quality figures** in a variety of hardcopy formats.

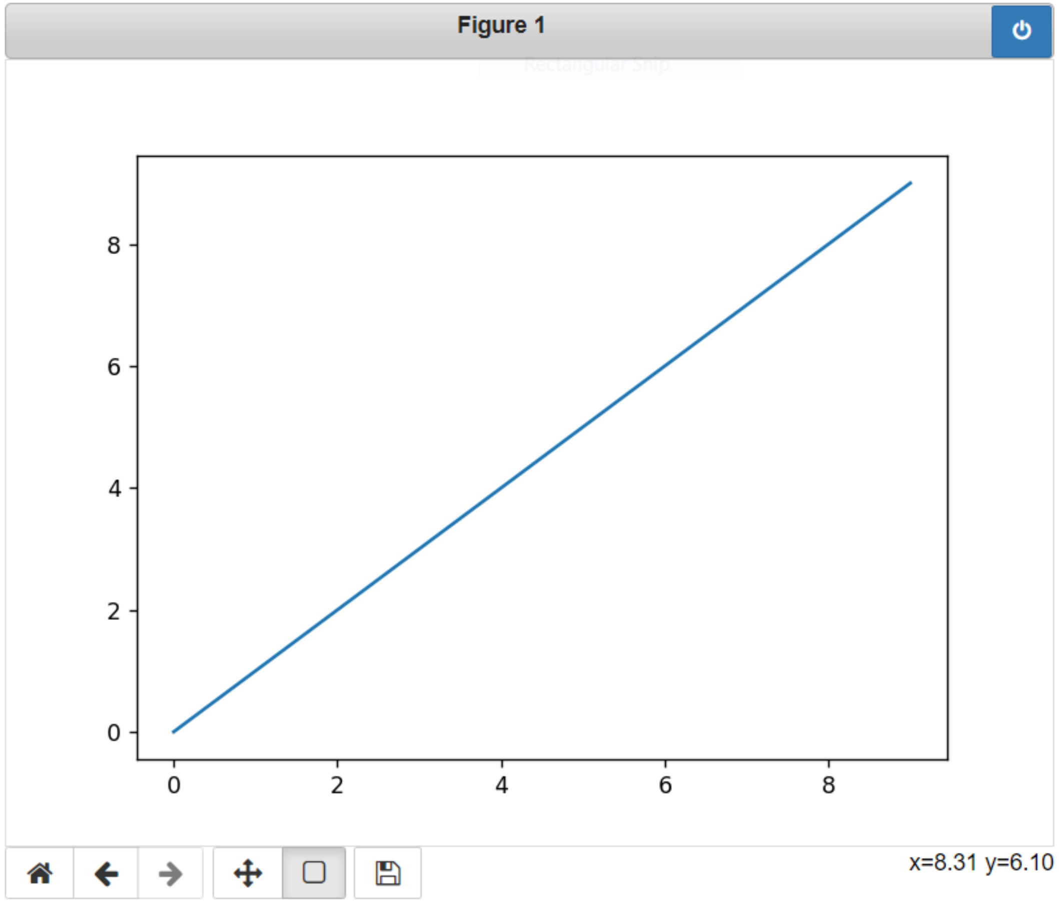
- **Website**: https://matplotlib.org/
- Also, check the **tutorial** package website: https://matplotlib.org/tutorials/introductory/pyplot.html

9.1 A Brief matplotlib API Primer

- To set up Jupyter Notebook, run `%matplotlib notebook` (`%matplotlib` in IPython).

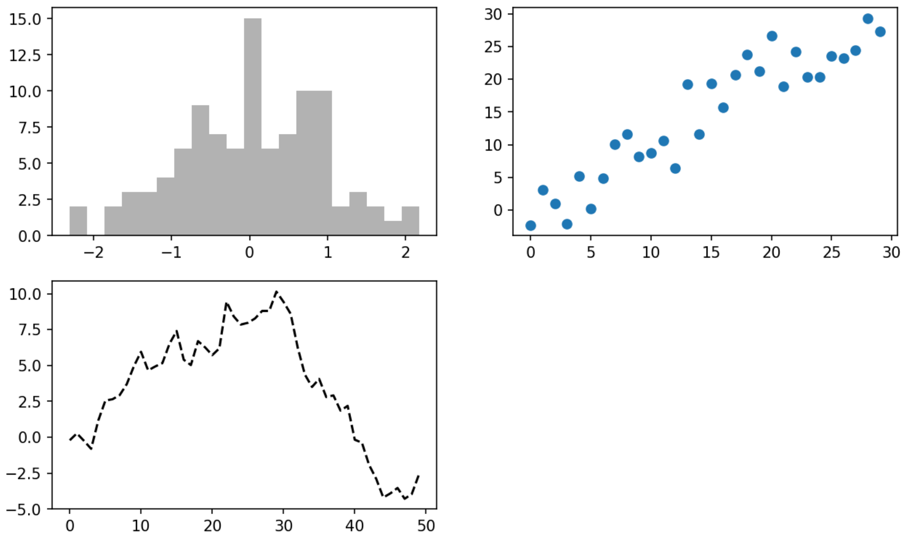
- Simple line plot:

```
import matplotlib.pyplot as plt
import numpy as np
data = np.arange(10)
plt.plot(data)
```



Figures and Subplots

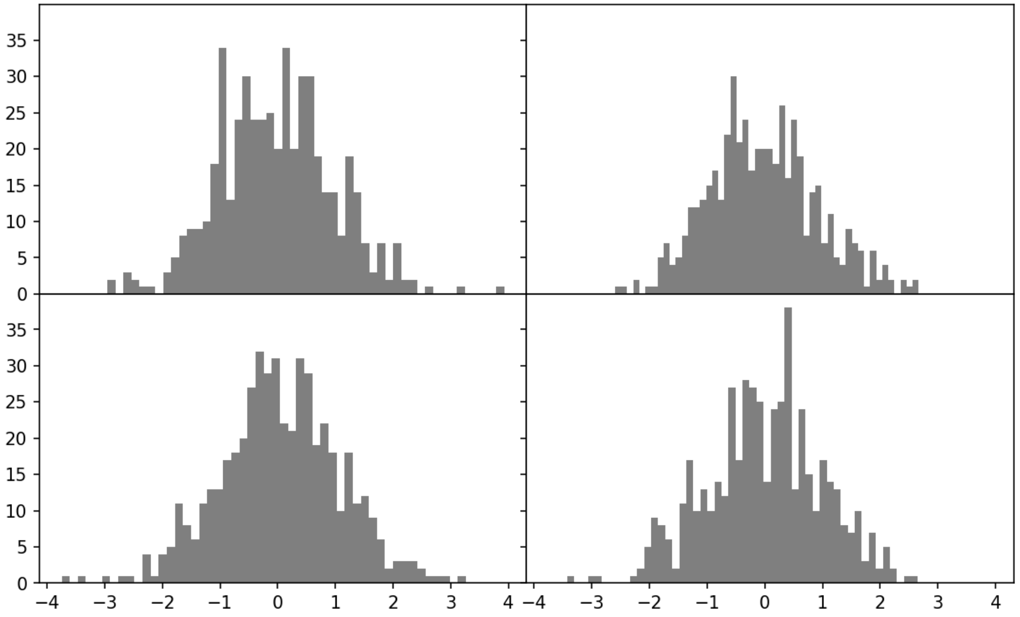
- Plots in matplotlib reside within a **Figure** object.
- You must create one or more **subplots** inside a blank figure.



```
fig = plt.figure(figsize=(4, 3))
ax1 = fig.add_subplot(2, 2, 1)
ax2 = fig.add_subplot(2, 2, 2)
ax3 = fig.add_subplot(2, 2, 3)
plt.plot(np.random.randn(50).cumsum(), 'k--')
_ = ax1.hist(np.random.randn(100),
    bins=20, color='k', alpha=0.3)
ax2.scatter(np.arange(30),
    np.arange(30) + 3 *
    np.random.randn(30))
```

Figures and Subplots

- Better to create a new figure and return a NumPy **array** containing the created **subplot objects**.

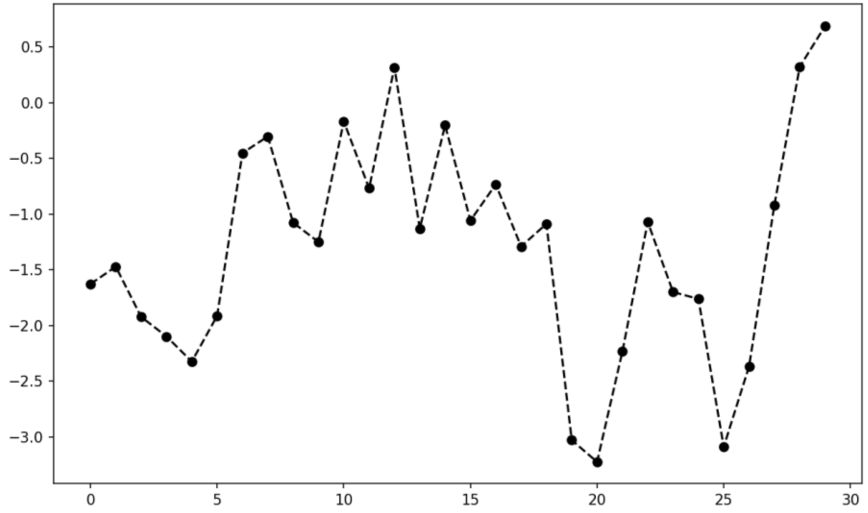


```
fig, axes = plt.subplots(2, 2,
   sharex=True, sharey=True)
for i in range(2):
   for j in range(2):
      axes[i, j].hist(
        np.random.randn(500),
        bins=50, color='k',
        alpha=0.5)
plt.subplots_adjust(wspace=0,
  hspace=0)
```

Colors, Markers, and Line Styles

- Specify color and style:
  - **String**
  - **Explicitly**
- Check options using **`plt.plot?`**

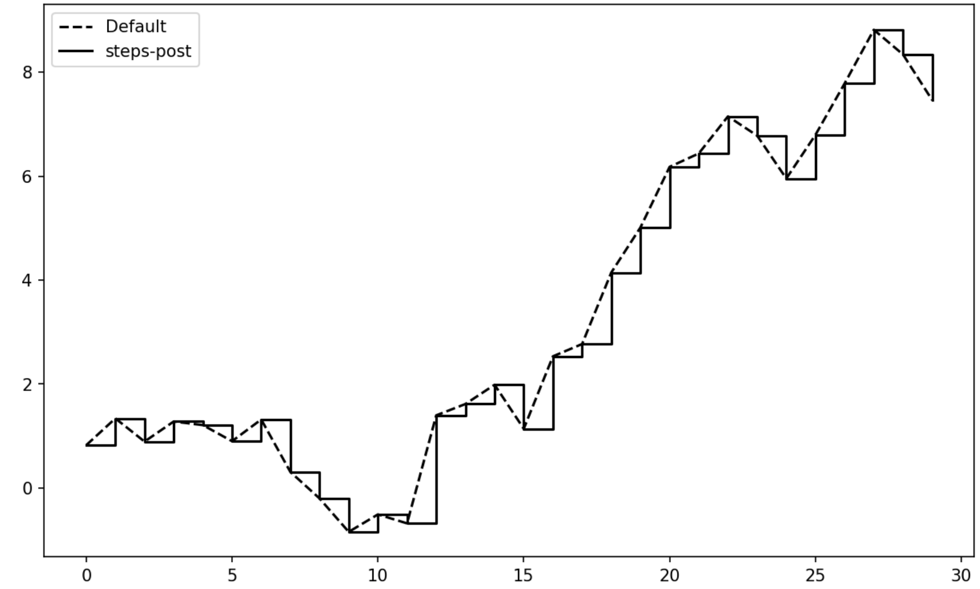
```
from numpy.random import randn
plt.plot(randn(30).cumsum(),
    'ko--')
plt.plot(randn(30).cumsum(),
    color='k', marker='o',
    linestyle='dashed')
```



Colors, Markers, and Line Styles

- You can specify the draw style:
  - **Linearly interpolated**
  - **Step**
  - **etc.**
- You can draw a **legend**.

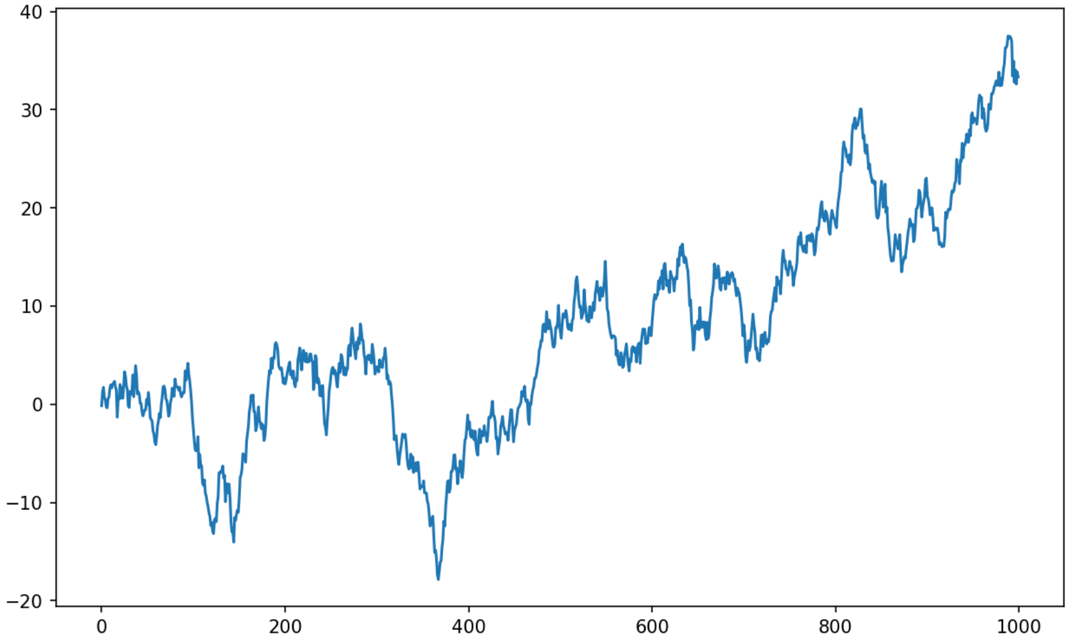
```
data = np.random.randn(30).cumsum()
plt.plot(data, 'k--',
    label='Default')
plt.plot(data, 'k-',
    drawstyle='steps-post',
    label='steps-post')
plt.legend(loc='best')
```



Ticks and Labels

- For plot decoration:
  - **Procedural** pyplot interface
  - **Object-oriented** interface

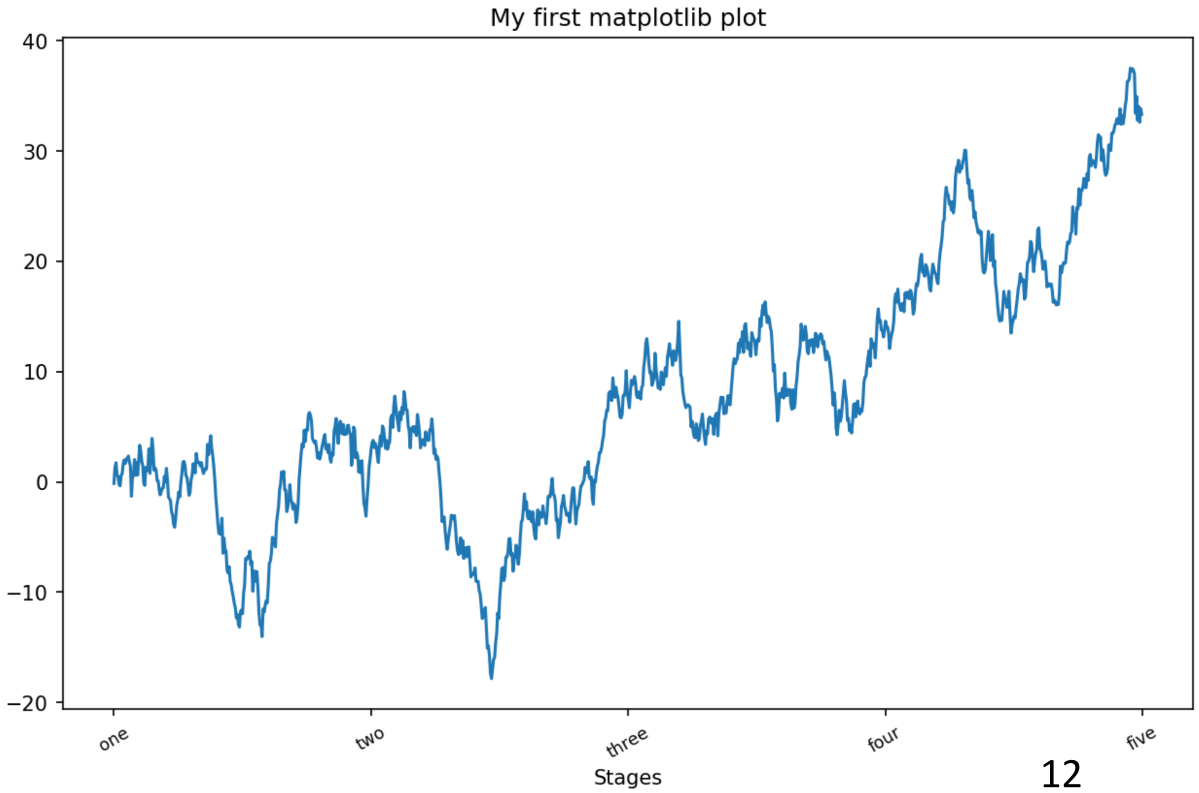
```
fig = plt.figure()
ax = fig.add_subplot(1, 1, 1)
ax.plot(np.random.randn(
                1000).cumsum())
```



Ticks and Labels

```
ticks = ax.set_xticks([0, 250, 500,
    750, 1000])
labels = ax.set_xticklabels(['one',
    'two', 'three', 'four',
    'five'], rotation=30,
    fontsize='small')
ax.set_title(
   'My first matplotlib plot')
ax.set_xlabel('Stages')
# Or:
props = {
   'title': 'My first plot',
   'xlabel': 'Stages'
}
ax.set(**props)
```

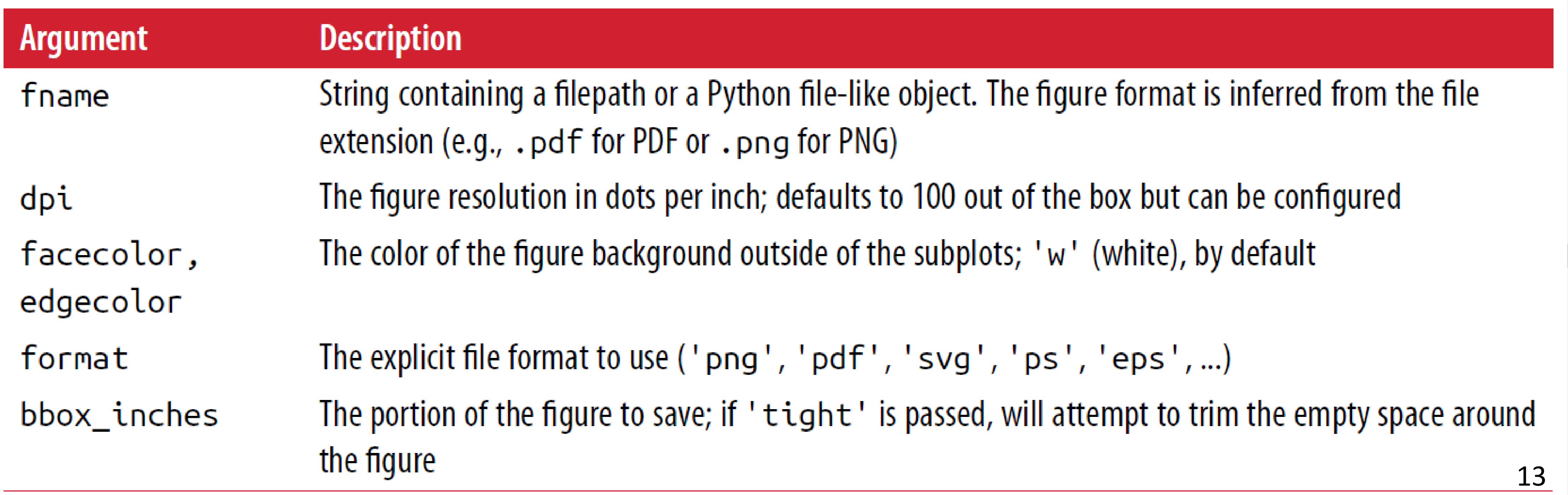
- Check [matplotlib.axes]()



Saving Plots to File

- When saving to a file, the **file extension** specifies the **image format**.

```
plt.savefig('figpath.png', dpi=400,
    bbox_inches='tight')
```



Argument	Description
fname	String containing a filepath or a Python file-like object. The figure format is inferred from the file extension (e.g., .pdf for PDF or .png for PNG)
dpi	The figure resolution in dots per inch; defaults to 100 out of the box but can be configured
facecolor, edgecolor	The color of the figure background outside of the subplots; 'w' (white), by default
format	The explicit file format to use ('png', 'pdf', 'svg', 'ps', 'eps', ...)
bbox_inches	The portion of the figure to save; if 'tight' is passed, will attempt to trim the empty space around the figure

matplotlib Configuration

- matplotlib comes configured with color schemes and defaults geared for publication.
- Can be customized:
  - Programmatically using the `rc` method
  - Configuration: `matplotlib/mpl-data/matplotlibrc`. Customize in your home directory as `.matplotlibrc`

```
plt.rc('figure', figsize=(10, 10))
font_options = {
    'family' : 'monospace',
    'weight' : 'bold',
    'size' : 'small'}
plt.rc('font', **font_options)
```

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9.2 Plotting with pandas and seaborn

- YouTube Video from **Kimberly Fessel**

Introduction to Seaborn | How seaborn Python works with matplotlib along with seaborn and pandas

https://youtu.be/vaf4ir8eT38

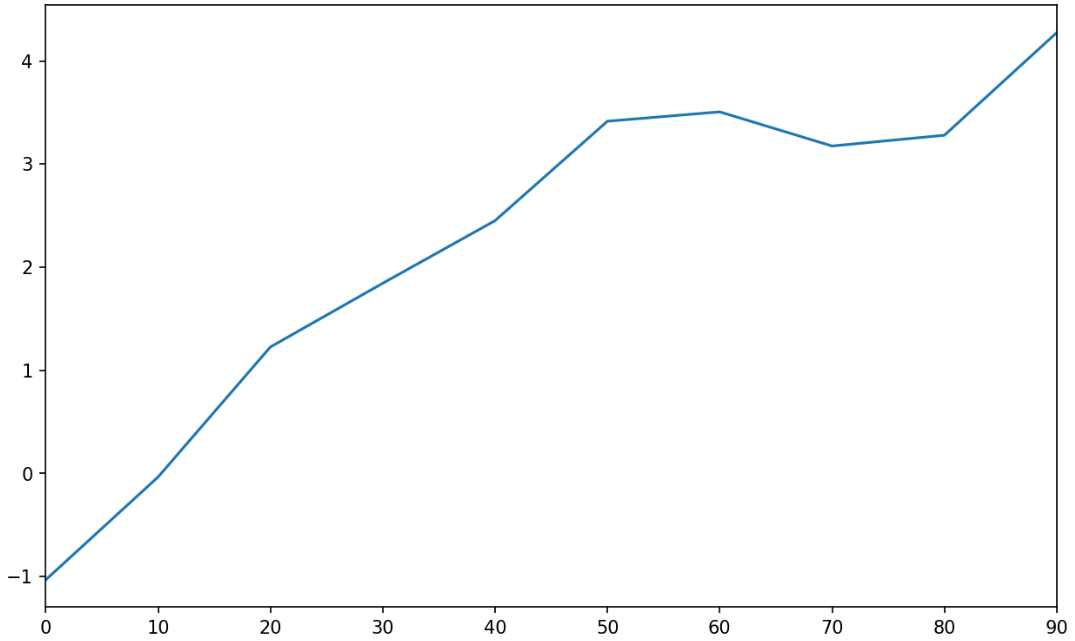
9.2 Plotting with pandas and seaborn

- **matplotlib is low-level tool**; you assemble a plot from its base components.
- Productive plotting is available through:
  - **pandas**
  - **seaborn** (https://seaborn.pydata.org/)
- Importing **seaborn** modifies the default matplotlib color schemes.

Line Plots

- Series and DataFrame have **plot** for making some basic plot types.

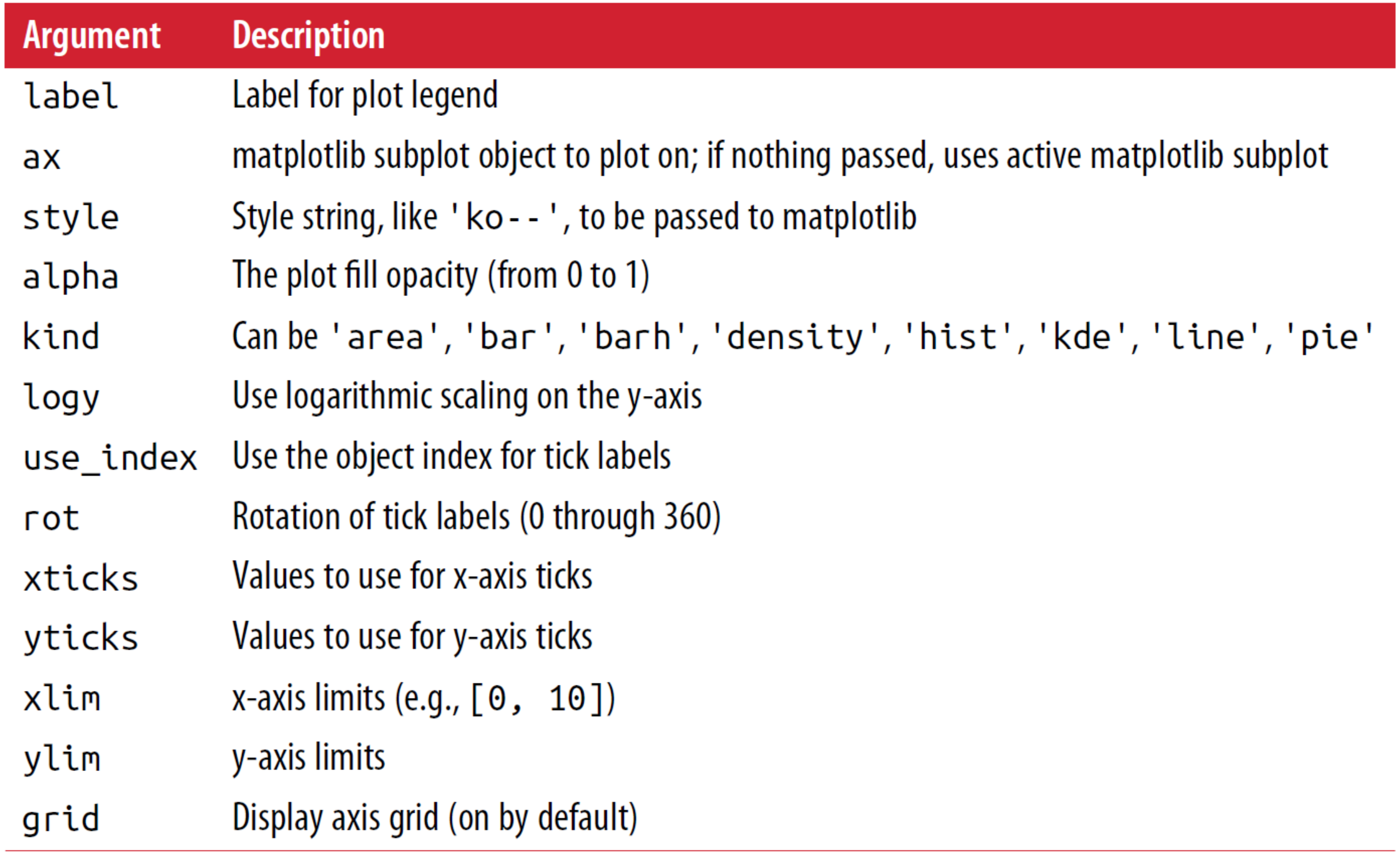
```
s = pd.Series(randn(10).cumsum(),
        index=np.arange(0, 100, 10))
s.plot()
```



Options:

`ax, use_index=False, xticks, xlim, yticks, ylim`

Series.plot method arguments



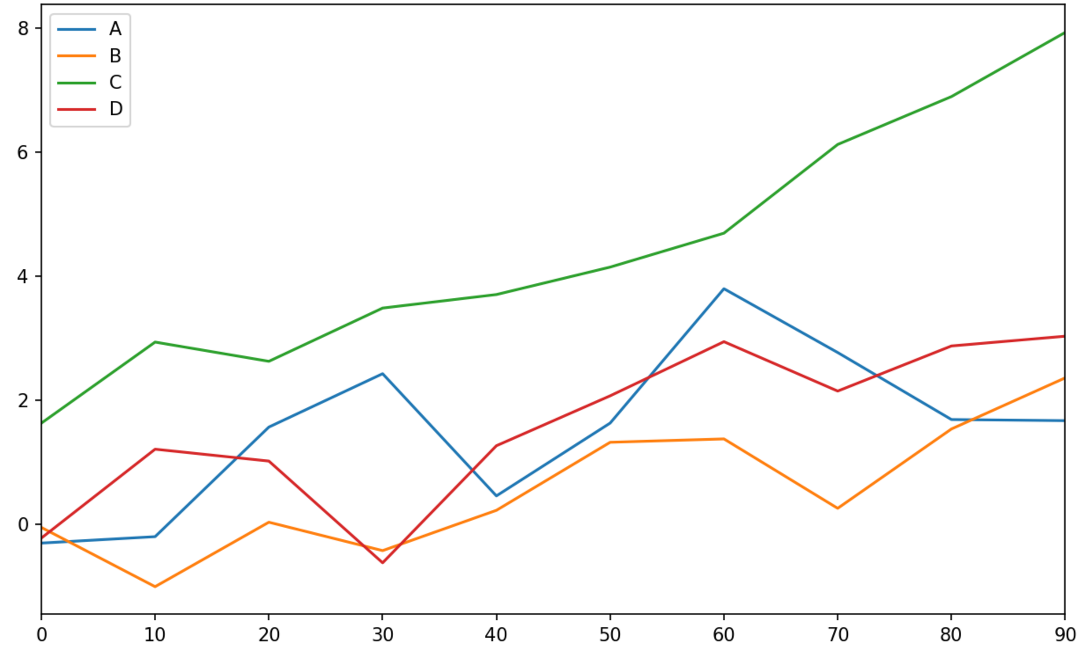
Argument	Description
`label`	Label for plot legend
`ax`	matplotlib subplot object to plot on; if nothing passed, uses active matplotlib subplot
`style`	Style string, like `'ko--'`, to be passed to matplotlib
`alpha`	The plot fill opacity (from 0 to 1)
`kind`	Can be `'area'`, `'bar'`, `'barh'`, `'density'`, `'hist'`, `'kde'`, `'line'`, `'pie'`
`logy`	Use logarithmic scaling on the y-axis
`use_index`	Use the object index for tick labels
`rot`	Rotation of tick labels (0 through 360)
`xticks`	Values to use for x-axis ticks
`yticks`	Values to use for y-axis ticks
`xlim`	x-axis limits (e.g., `[0, 10]`)
`ylim`	y-axis limits
`grid`	Display axis grid (on by default)

Line Plots

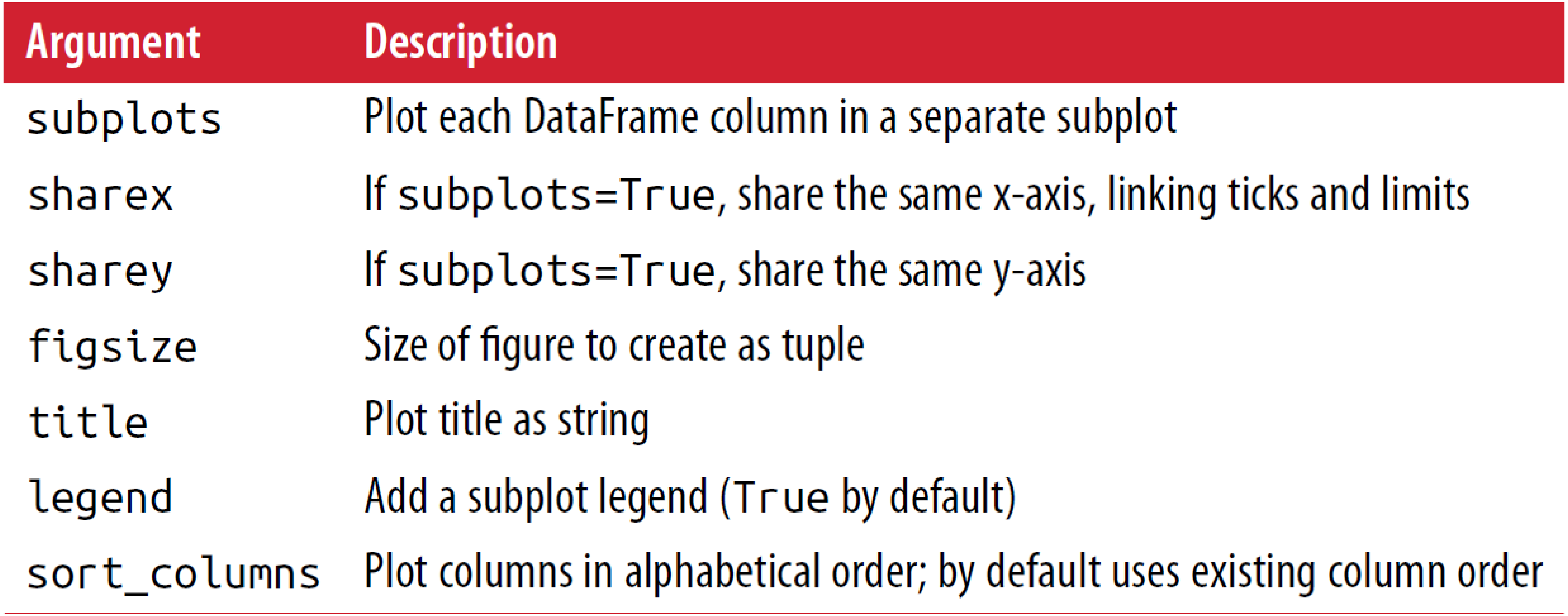
- DataFrame plots each of its **columns** as a **different line** on the same subplot, creating a **legend** automatically.

```
df = pd.DataFrame(randn(10,
        4).cumsum(0),
        columns=['A', 'B', 'C', 'D'],
        index=np.arange(0, 100, 10))
df.plot()
```

Equivalent to `df.plot.line()`



DataFrame-specific plot arguments

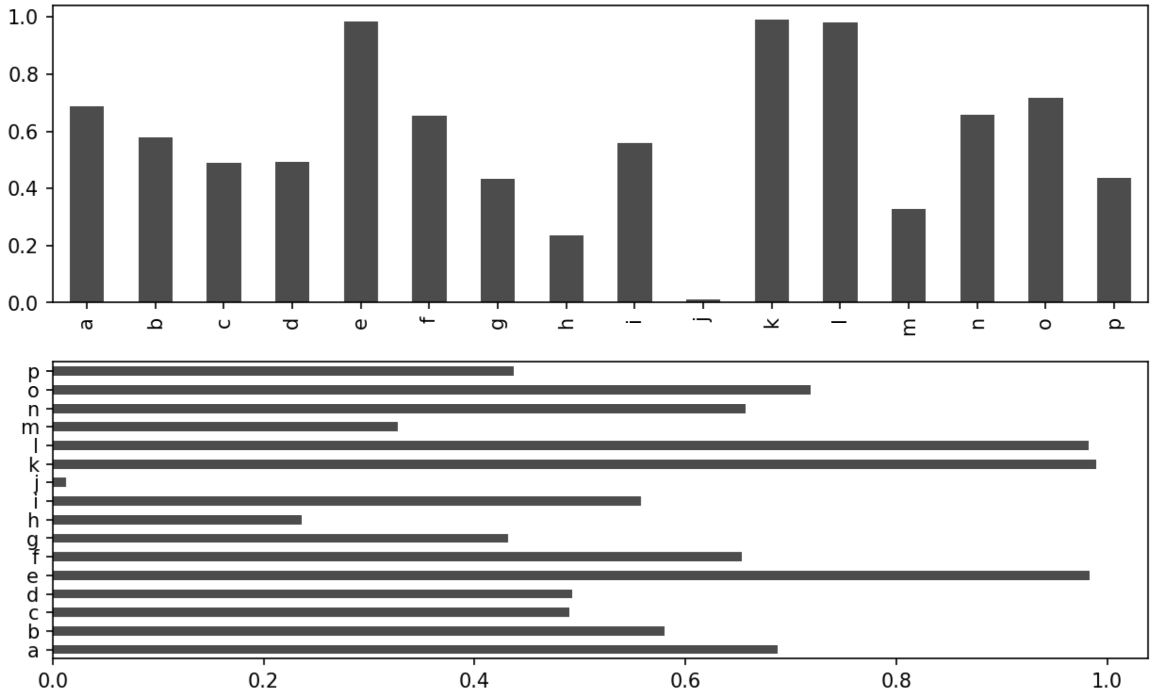


Argument	Description
`subplots`	Plot each DataFrame column in a separate subplot
`sharex`	If `subplots=True`, share the same x-axis, linking ticks and limits
`sharey`	If `subplots=True`, share the same y-axis
`figsize`	Size of figure to create as tuple
`title`	Plot title as string
`legend`	Add a subplot legend (`True` by default)
`sort_columns`	Plot columns in alphabetical order; by default uses existing column order

Bar Plots

- The `plot.bar` and `plot.barh` make vertical and horizontal bar plots.

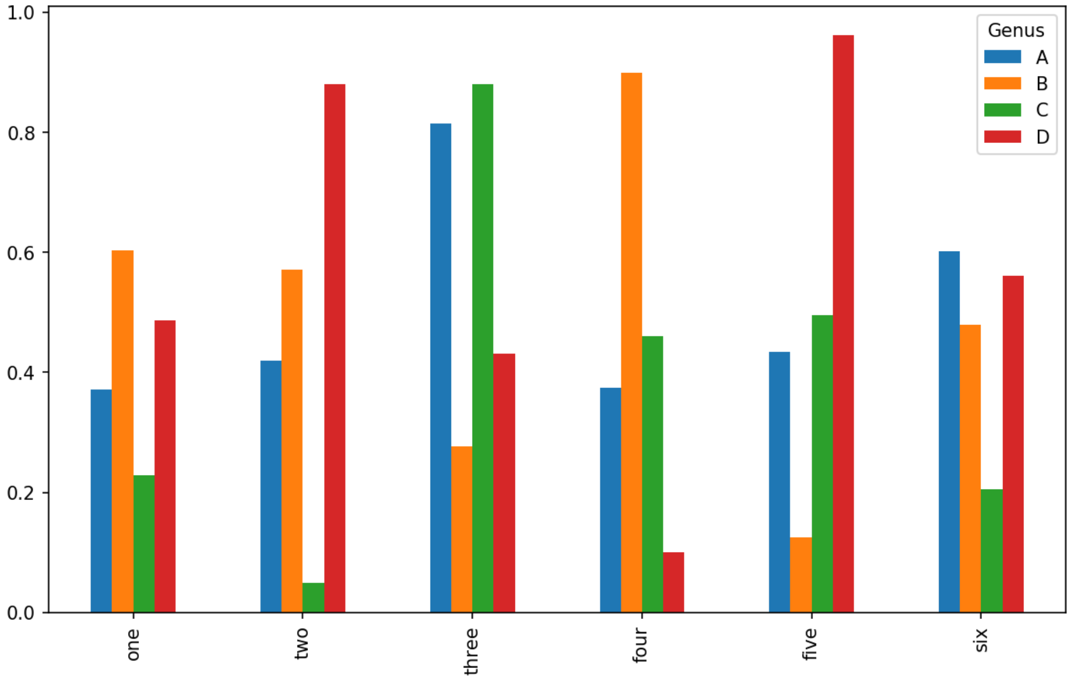
```
fig, axes = plt.subplots(2, 1)
data = pd.Series(rand(16),
    index=list('abcdefghijklmnop'))
data.plot.bar(ax=axes[0],
    color='k', alpha=0.7)
data.plot.barh(ax=axes[1],
    color='k', alpha=0.7)
```



Bar Plots

- With a DataFrame, bar plots **group** the values in **each row** together in a group in bars, side by side, for each value.

```
df.plot.bar()
```

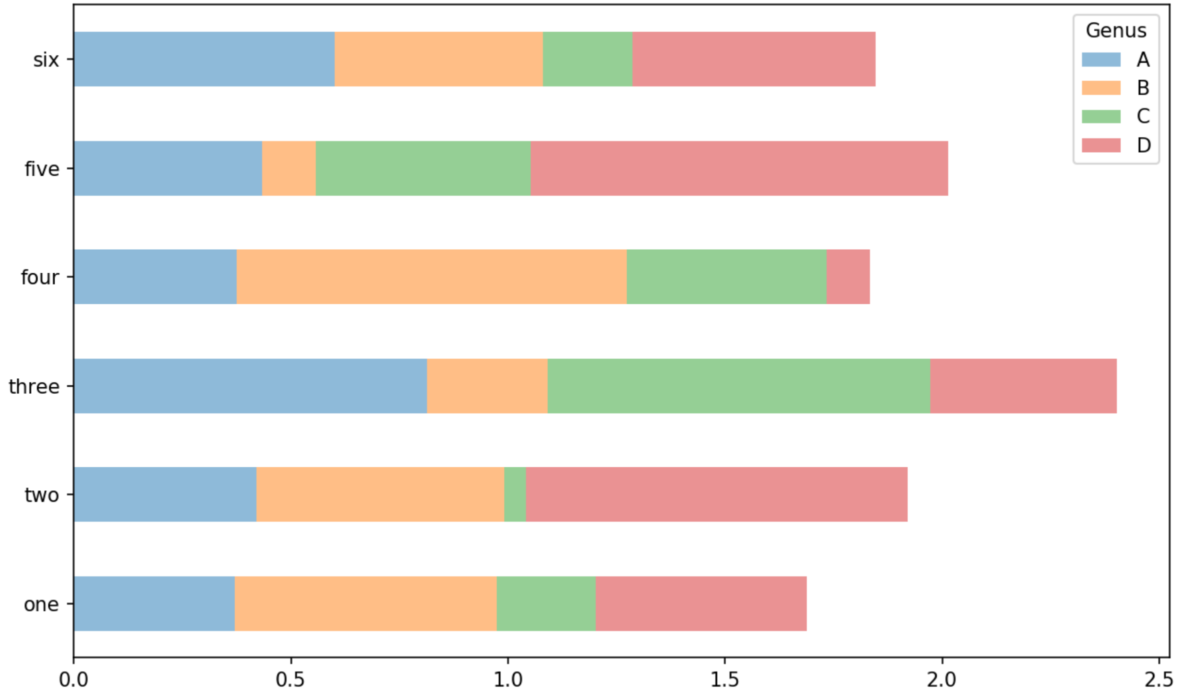


```
df
Genus         A         B         C         D
one    0.801554  0.094551  0.469551  0.619210
two    0.208189  0.792578  0.648303  0.260912
three  0.642697  0.847883  0.767702  0.856446
four   0.113493  0.083676  0.283905  0.023767
five   0.220087  0.573322  0.800078  0.514133
six    0.929547  0.272519  0.783754  0.007303
```

Bar Plots

- We create stacked bar plots from a DataFrame by passing **stacked=True**.

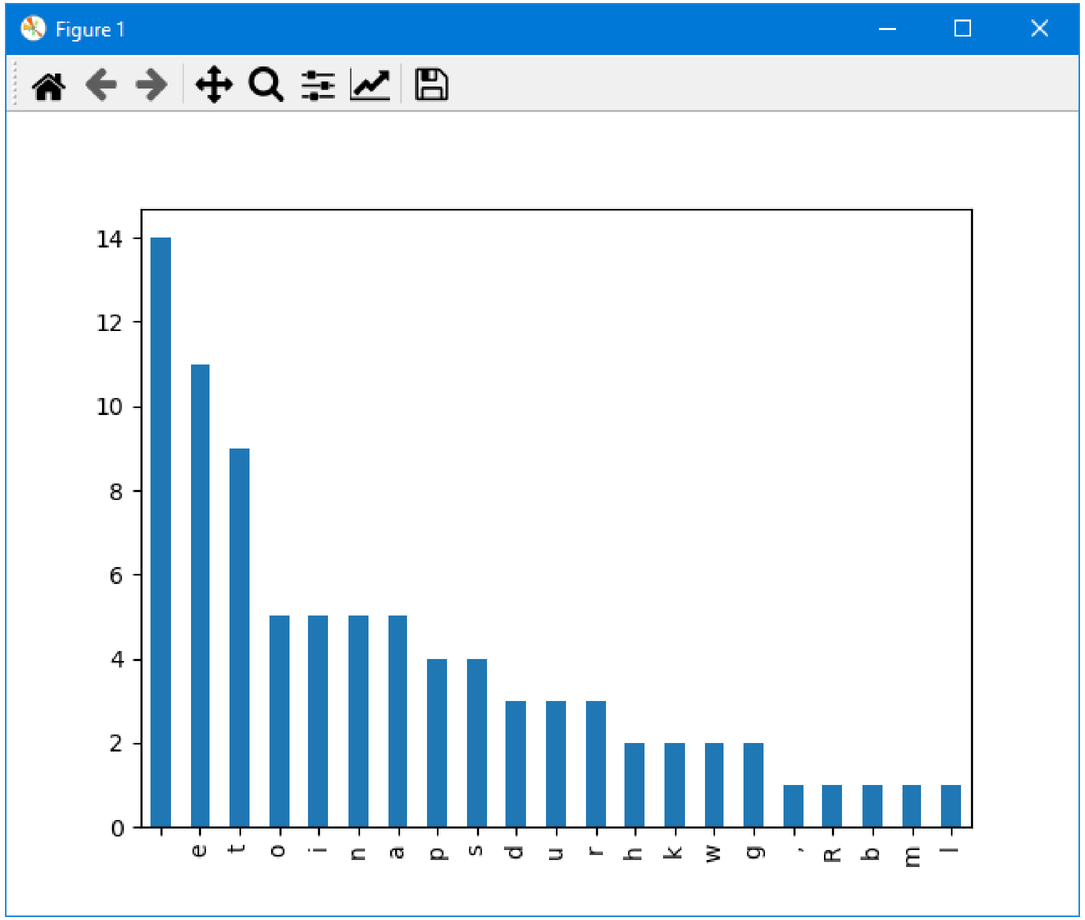
```
df.plot.barh(stacked=True,
    alpha=0.5)
```



Bar Plots

- A useful recipe for bar plots is to visualize a Series’s **value frequency** `s.value_counts().plot.bar()`.

```
s = pd.Series(list('Returning to the tipping dataset used earlier in the book, suppose we wanted to make'))
s.value_counts().plot.bar()
```



Bar Plots

- **Example**: Tipping Dataset

  Make a stacked bar plot showing the **percentage** of data points for each **party size** on each **day**.

- Hint: use `crosstab`

```
tips = pd.read_csv('tips.csv')

party_counts = pd.crosstab(
    tips['day'], tips['size'])
```

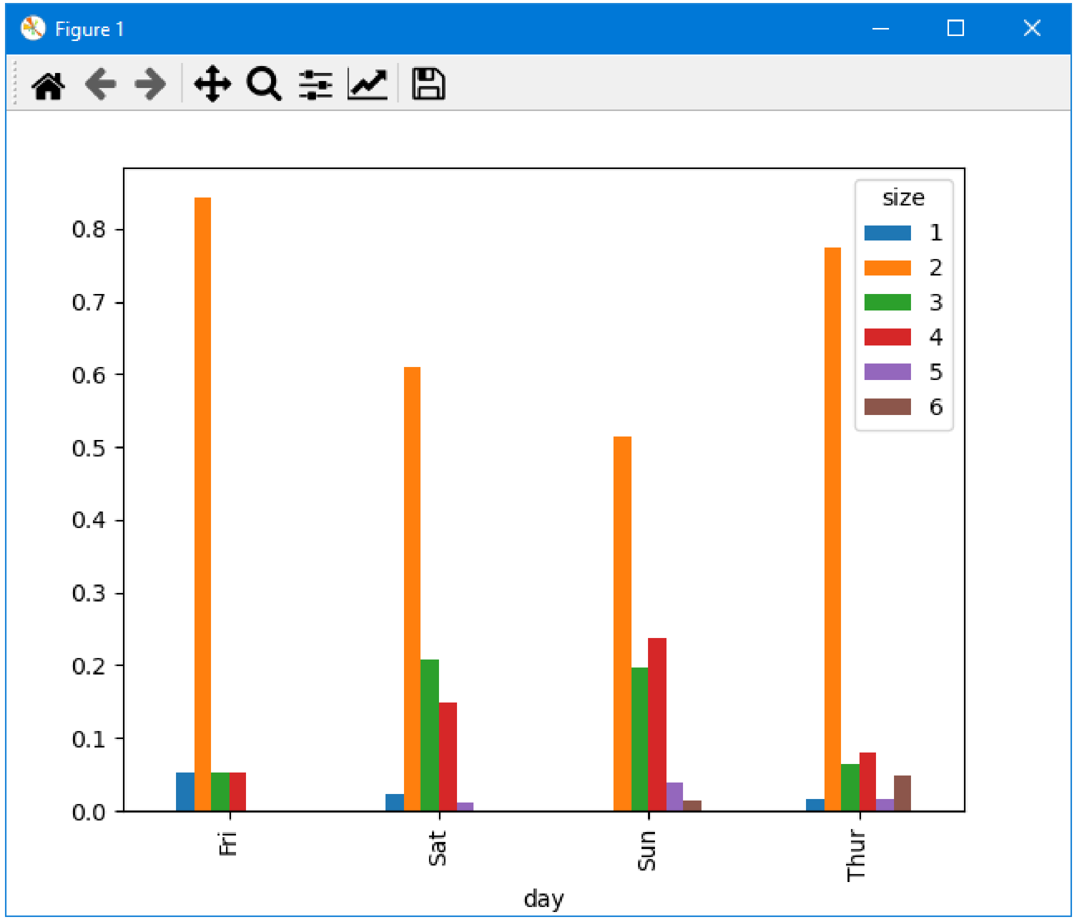
```
party_counts
size  1   2   3   4  5  6
day
Fri   1  16   1   1  0  0
Sat   2  53  18  13  1  0
Sun   0  39  15  18  3  1
Thur  1  48   4   5  1  3
```

Bar Plots

```
party_pcts = party_counts.div(
     party_counts.sum(1), axis=0)
```

```
party_pcts
size          1         2         3         4         5         6
day
Fri    0.052632  0.842105  0.052632  0.052632  0.000000  0.000000
Sat    0.022989  0.609195  0.206897  0.149425  0.011494  0.000000
Sun    0.000000  0.513158  0.197368  0.236842  0.039474  0.013158
Thur   0.016129  0.774194  0.064516  0.080645  0.016129  0.048387
```

```
party_pcts.plot.bar()
```



Bar Plots (seaborn)

- **Example**: Use **seaborn** to visualize **tip percent**.

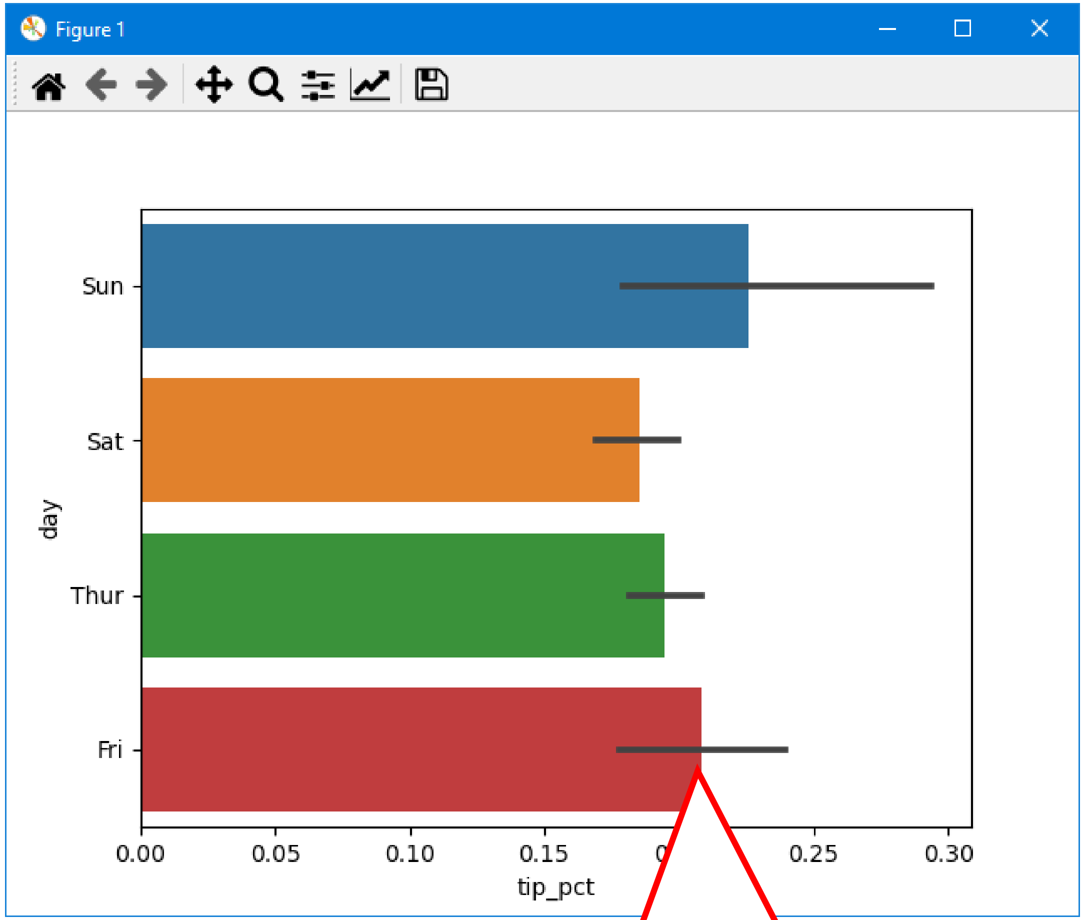
```
import seaborn as sns

tips['tip_pct'] = tips['tip'] / 
(tips['total_bill'] - tips['tip'])

tips.head()
```

```
   total_bill   tip smoker  day    time  size   tip_pct
0       16.99  1.01     No  Sun  Dinner     2  0.063204
1       10.34  1.66     No  Sun  Dinner     3  0.191244
2       21.01  3.50     No  Sun  Dinner     3  0.199886
3       23.68  3.31     No  Sun  Dinner     2  0.162494
4       24.59  3.61     No  Sun  Dinner     4  0.172069
```

```
sns.barplot(x='tip_pct', y='day',
        data=tips, orient='h')
```

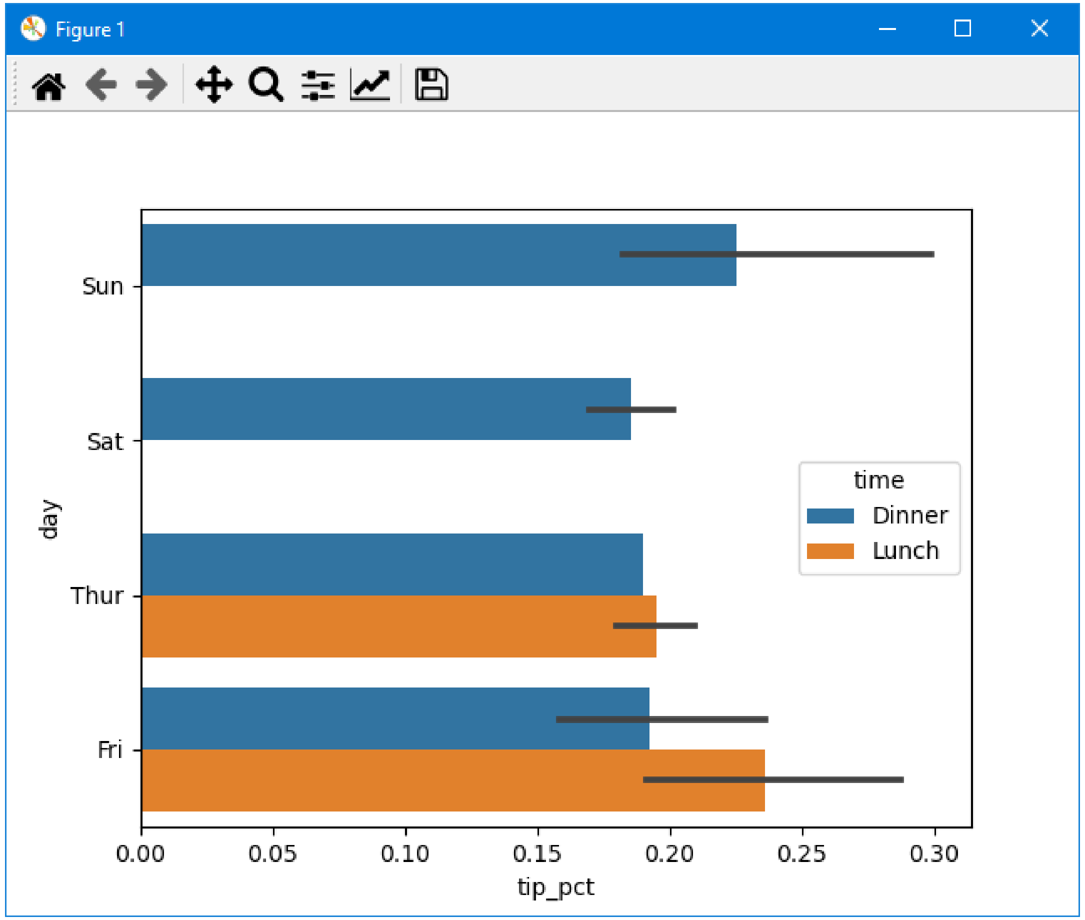


Averages with 95% confidence interval

Bar Plots (seaborn)

- seaborn.barplot has a hue option that enables us to split by an additional categorical value.

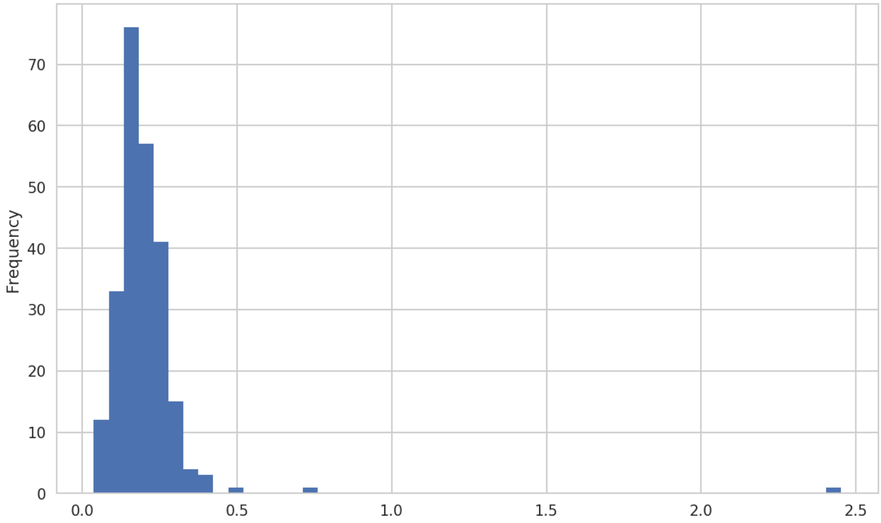
```
sns.barplot(x='tip_pct', y='day',
        hue='time', data=tips,
        orient='h')
```



Histograms and Density Plots

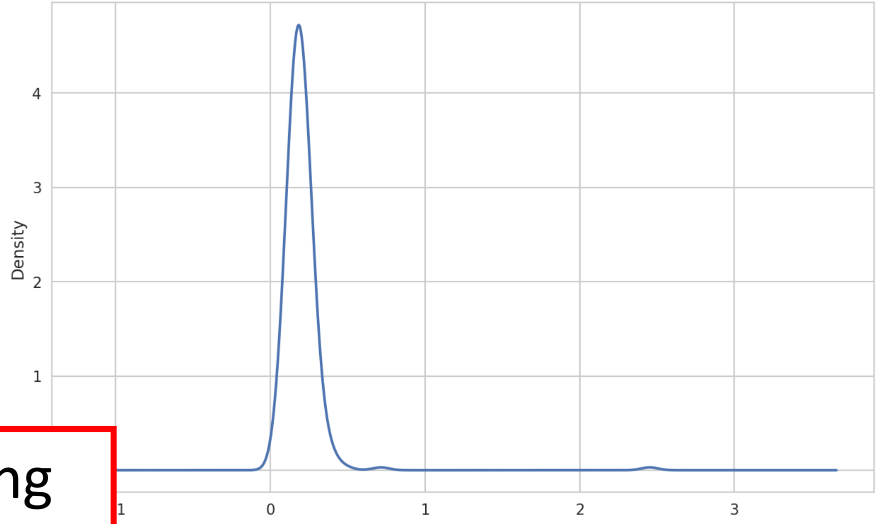
- A **histogram** is a kind of bar plot that gives a discretized display of value frequency.

```
tips['tip_pct'].plot.hist(bins=50)
```



- A **density** plot is formed by computing an estimate of a CPD for the observed data.

```
tips['tip_pct'].plot.density()
```



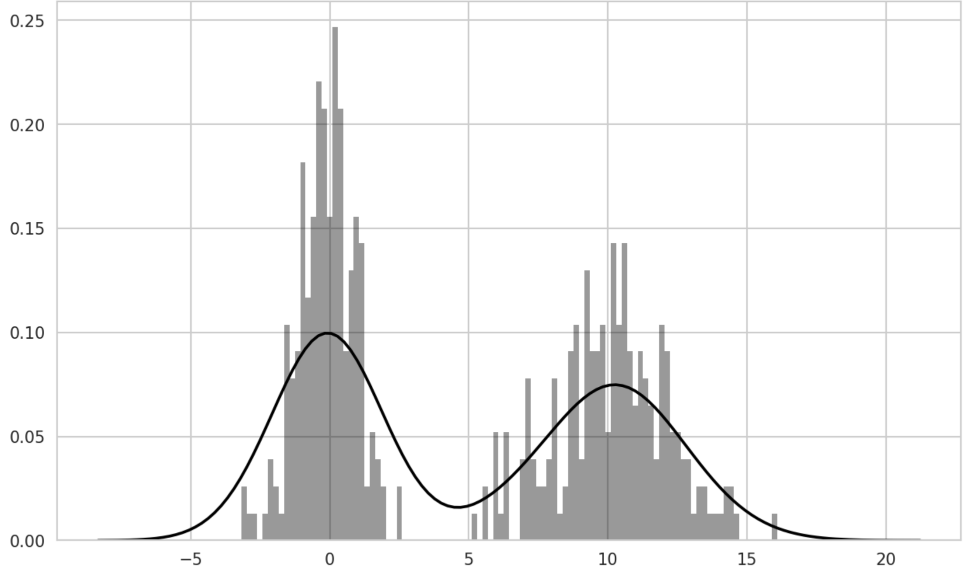
Same as kernel density estimate (KDE) using **plot.kde**

Histograms and Density Plots

- Seaborn's **distplot** can plot both a **histogram** and a **continuous density estimate** simultaneously.
- **Example**: bimodal normal distributions.

```
comp1 = np.random.normal(0, 1,
                 size=200)
comp2 = np.random.normal(10, 2,
                 size=200)
```

```
values = pd.Series(np.concatenate(
              [comp1, comp2]))
sns.distplot(values, bins=100,
             color='k')
```

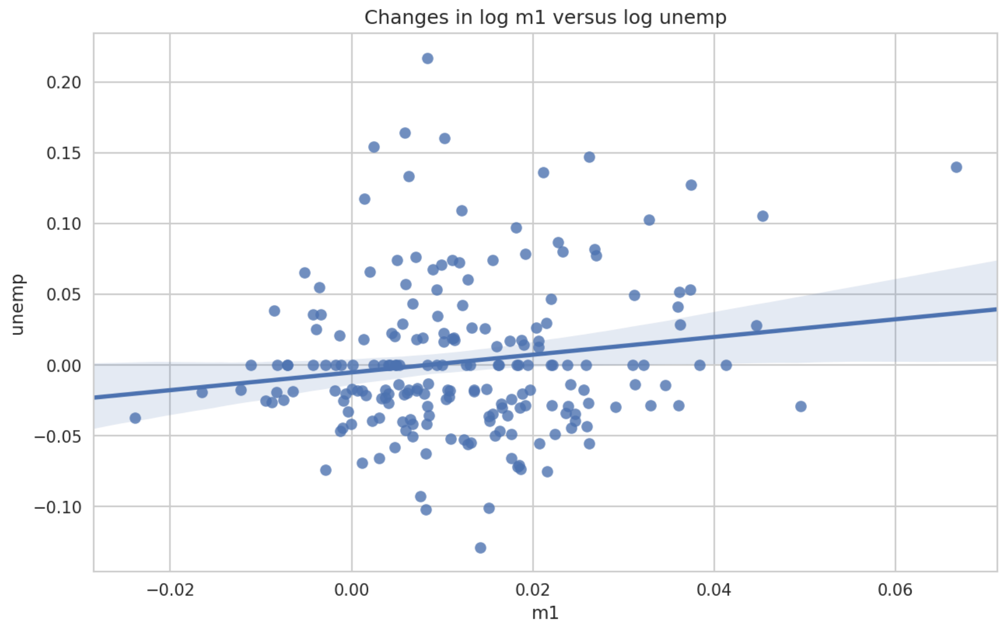


Scatter or Point Plots

- Point plots or **scatter plots** can be a useful way of **examining** the **relationship** between two one-dimensional data series.
- **Example**: macrodata.csv

```
macro = pd.read_csv(
            'macrodata.csv')
data = macro[['cpi', 'm1',
              'tbilrate', 'unemp']]
trans_data = np.log(
              data).diff().dropna()
```

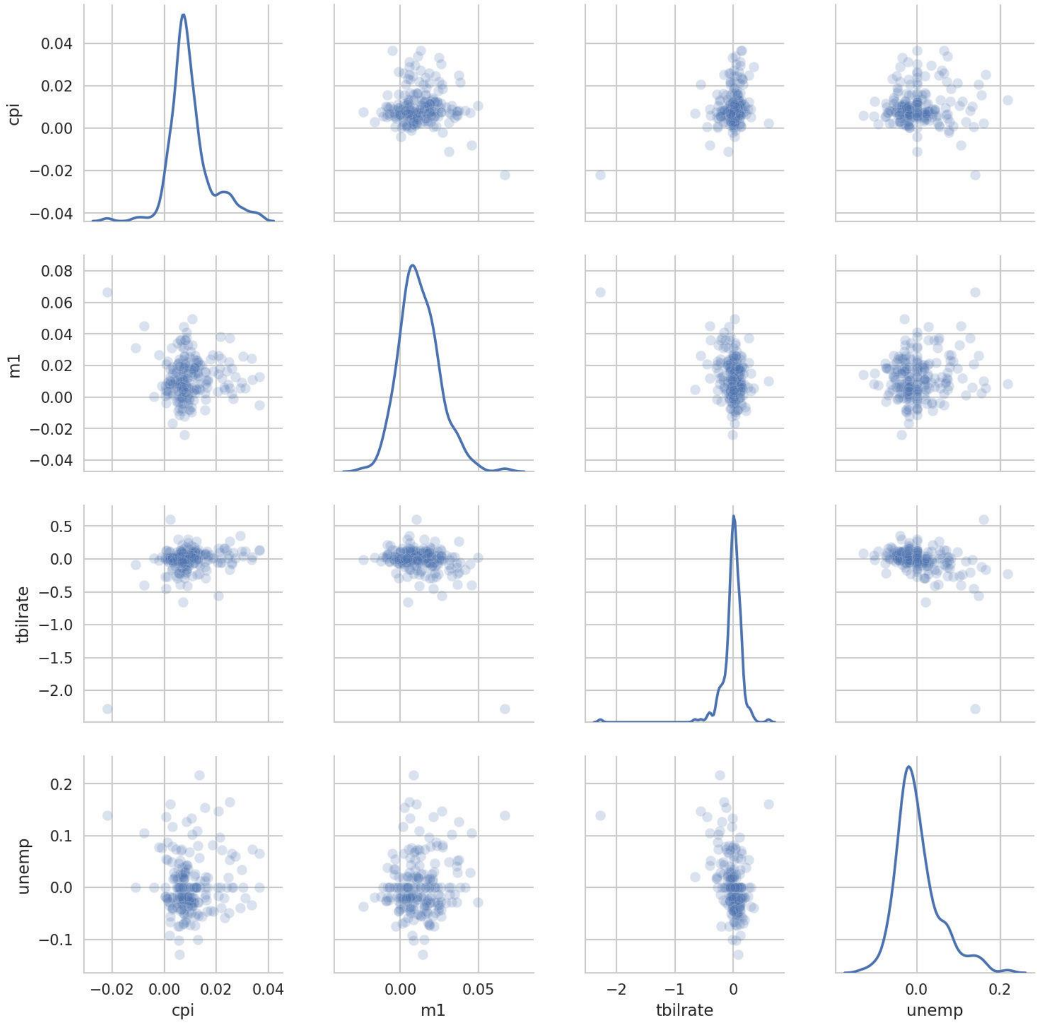
```
sns.regplot('m1', 'unemp',
            data=trans_data)
plt.title('Changes in log %s versus
log %s' % ('m1', 'unemp'))
```



Scatter or Point Plots

- In exploratory data analysis it’s helpful to look at all the scatter plots; this is known as **scatter plot matrix**.

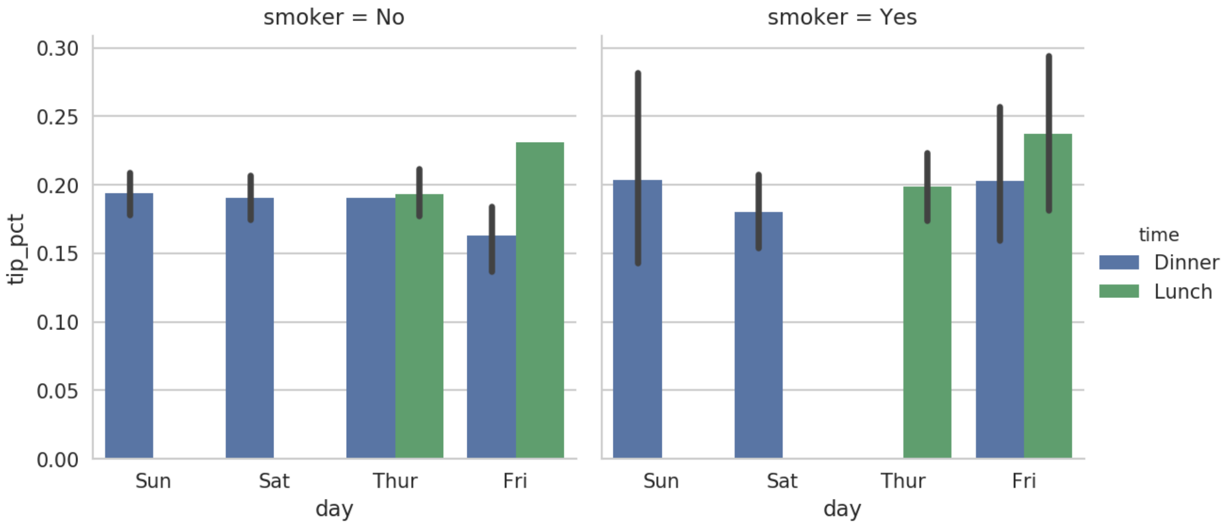
```
sns.pairplot(trans_data,
     diag_kind='kde',
     plot_kws={'alpha': 0.2})
```



Facet Grids and Categorical Data

- You can use **facet grids** to visualize data with many categorical variables.
- **Example**: Compare tip percentage with smoking.

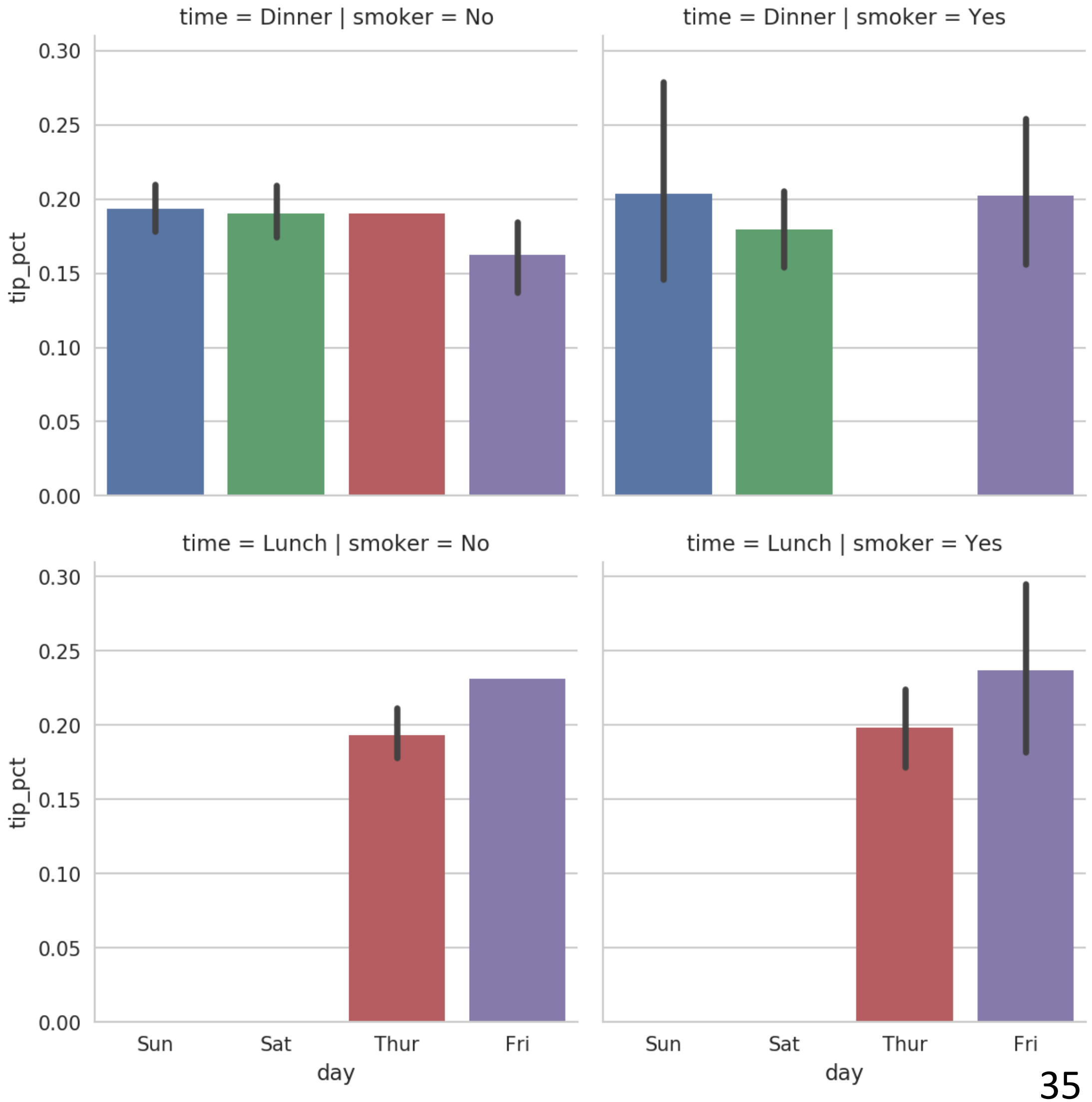
```
sns.factorplot(x='day',
        y='tip_pct', hue='time',
        col='smoker', kind='bar',
        data=tips[tips.tip_pct < 1])
```



Facet Grids and Categorical Data

- **Example**: Show time in a different facet.

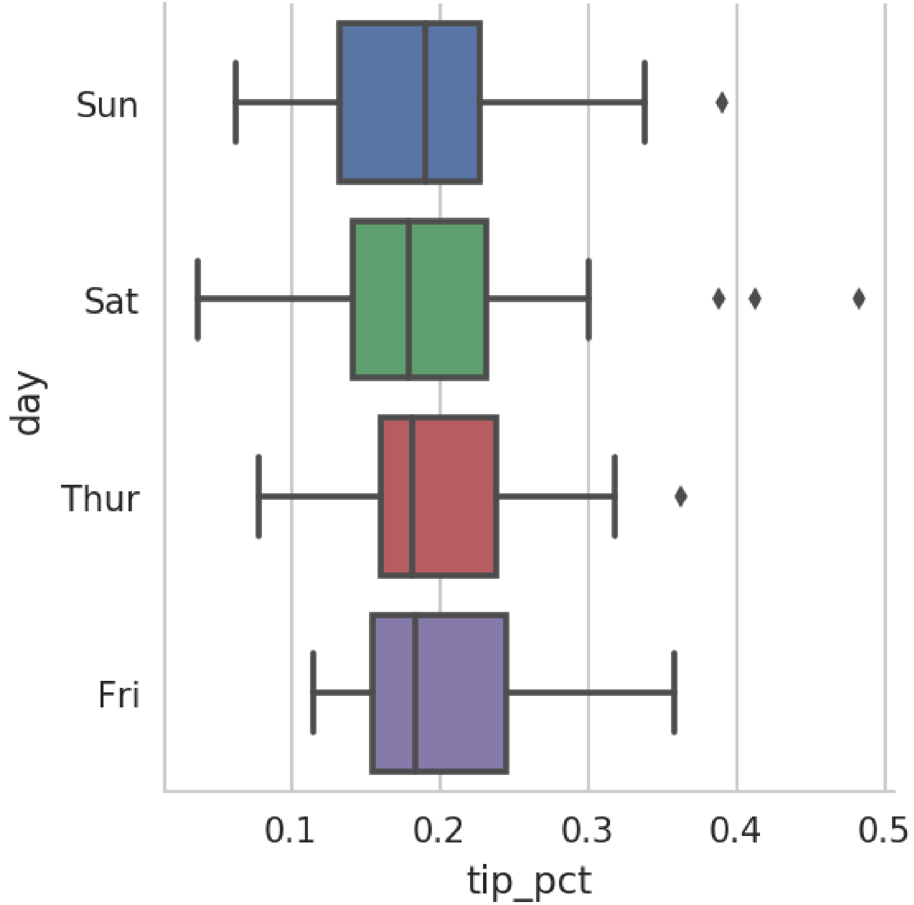
```
sns.factorplot(x='day',
         y='tip_pct', row='time',
         col='smoker', kind='bar',
         data=tips[tips.tip_pct < 1])
```



Facet Grids and Categorical Data

- **Example**: Draw a box plot to show the median, quartiles, and outliers.

```
sns.factorplot(x='tip_pct',
      y='day', kind='box',
      data=tips[tips.tip_pct < 0.5])
```



Homework

- Solve the homework on **data wrangling and visualization**.

Summary

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