Did you know Matplotlib could do that?

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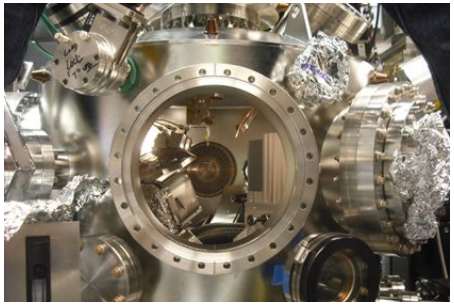
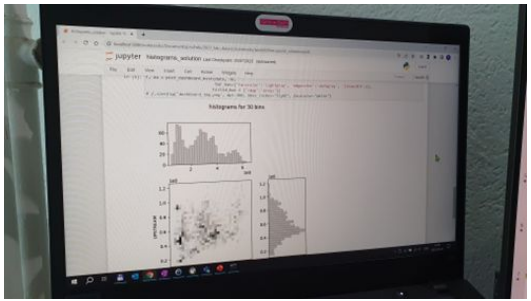
Swiss Python Summit 2023, 21.09.2023

About me





ETH zürich

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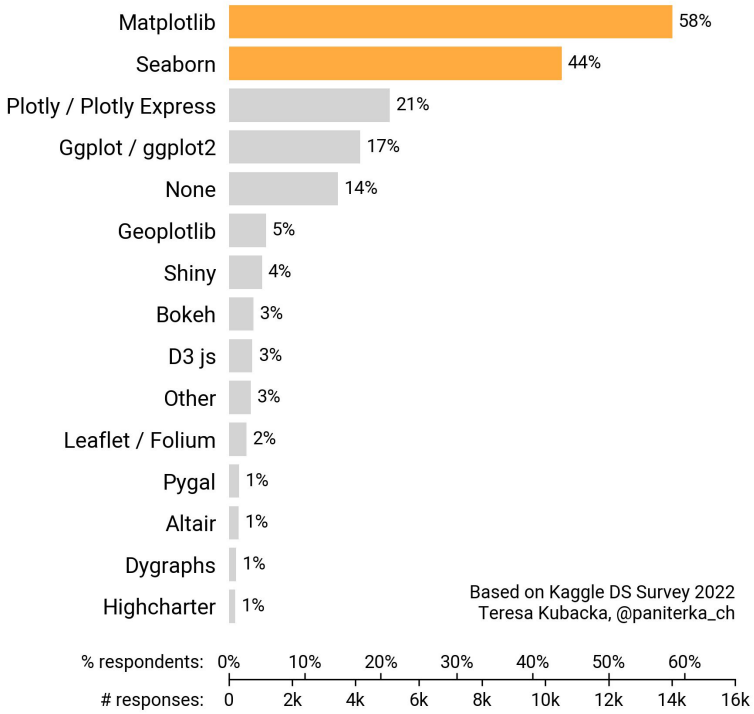
Almost 60% of data scientists use MPL on a regular basis



Posted by u/[deleted] 4 years ago

201

Am I the only one who hates matplotlib?

Ive been working with python for 3-4 years. Some breaks in this timespan and a lot of different projects.

I love to do so many different projects because there are always new exciting librarys to explore. But matplotlib was since the beginning horror for me. Its the only library where I have massive problems to understand the docs and the basic concept.

Posted by u/rlh1994 3 years ago

Does matplotlib ever actually make sense or do you just learn it by heart?

smabie on Nov 16, 2019 | parent | context | favorite | on: Effectively Using Matplotlib (2017)

Matplotlib belongs to the worst category of software: very powerful and very awful. Nothing makes any sense and it's so profoundly unintuitive it almost feels like I'm being pranked. But, of course, use it I must.

Pandas also comes off as an unintuitive joke, but my displeasure with it has *mostly* worn off. Matplotlib however makes me feel angry pretty much everyday.

Posted by u/Live_Solution_8851 9 months ago

Matplotlib sucks

discussion

Matplotlib is the worst plotting library i have ever used:

MPL is super powerful!

3D plotting

animations

easy switch between exporting to
vector or raster formats

interactive charts

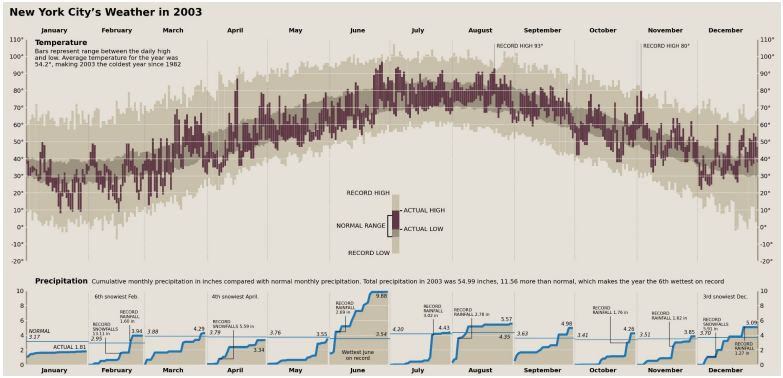
many different renderers

native Python GUIs, web-apps

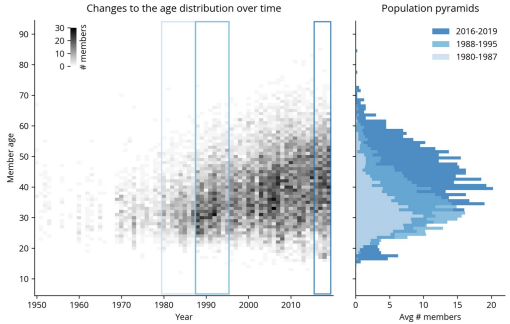
you can quite easily build your own
data-driven components from scratch

customized, beautiful charts

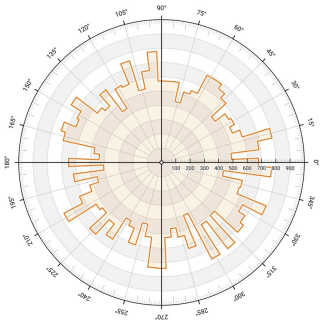
Dataviz for analytics



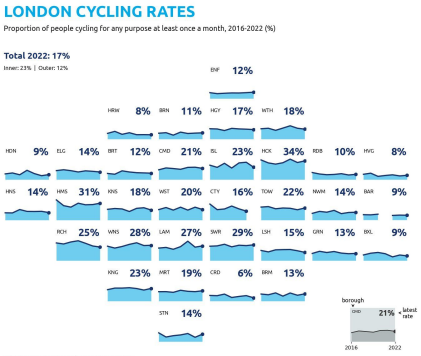
Cameron Riddell
(after E. Tufte)



Teresa Kubacka

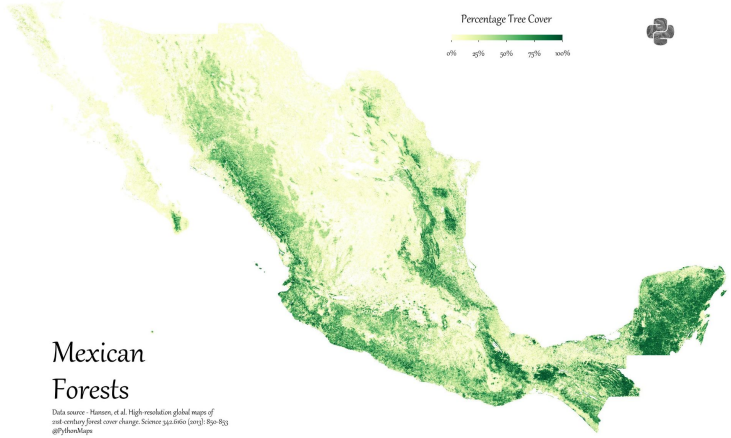


Nicolas P. Rougier

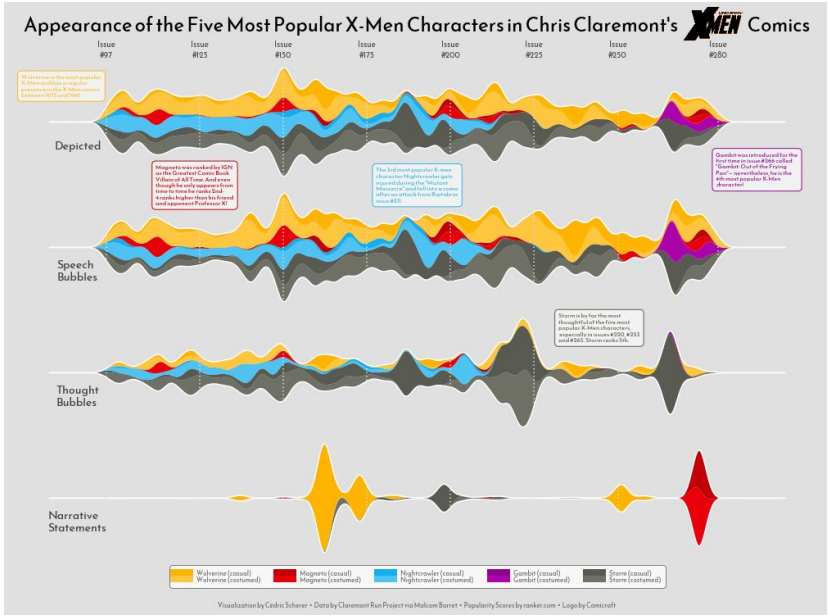


Lisa Hornung

Infographics

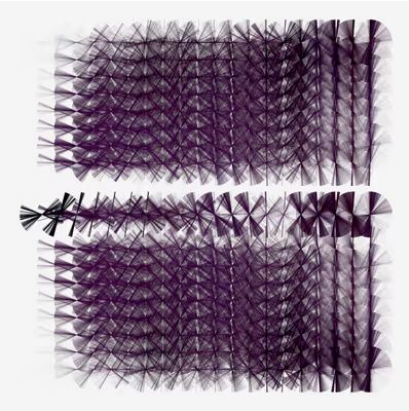


Adam Symington / PythonMaps

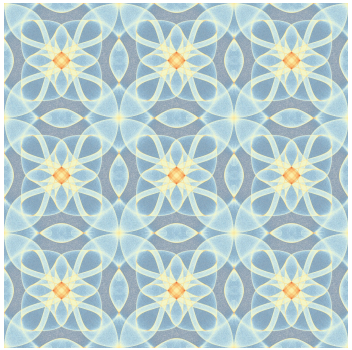


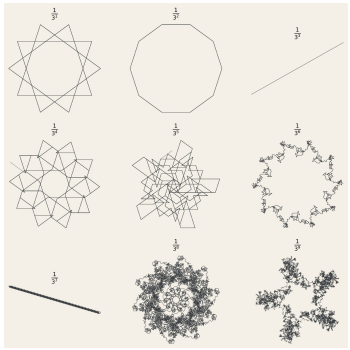
Tomi Capretto (after C. Scherer)

Data art

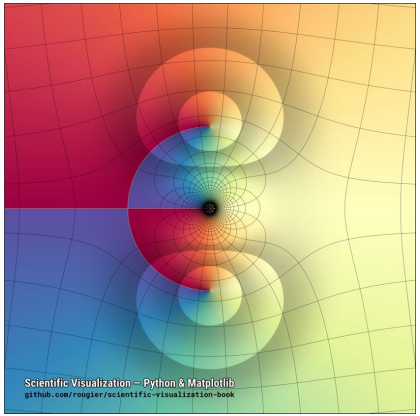


chiko.art





Simone Conradi



Nicolas P. Rougier

Plan for today

1

Understand the inner workings of MPL

2

Get familiar with some of the awesome parts of MPL

3

Your visualization is code:

- DRY: functions, properties as variables, stylesheets…
- Loops, zip, enumerate…

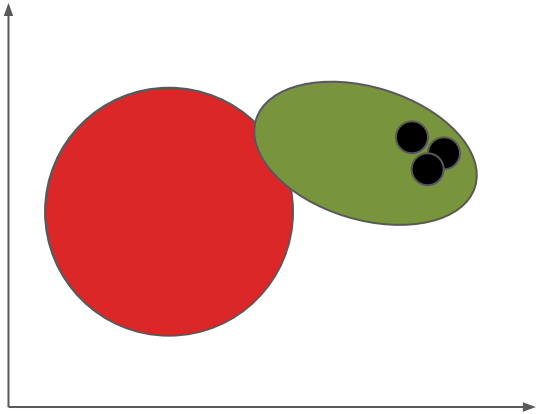
4

How to design better charts

1: Understand MPL

Dataviz and intuition

We have a natural intuition for working with visuals



Dataviz and intuition

We have some intuition for data visualization (that we train since our early days)

https://www.walmart.com/ip/KMTJT-Montessori-Toys-1-2-3-Year-Old-Color-Sorting-Stacking-Matching-Learning-Toddlers-1-3-Olds-Educational-Toy-Gift-Boy-Girl/3704572425

https://www.glitteronadime.com/make-a-rainbow-castle-with-lego-duplo-blocks/

Dataviz and intuition

But we don’t have that same kind of intuition for coding charts!

```
fig, ax = plt.subplots()
ax.plot(x, y_est, '-')
ax.fill_between(x,
    y_est - y_err, y_est + y_err,
    alpha=0.2)
ax.plot(x, y, 'o', color='tab:brown')
```

Matplotlib

```
(
    ggplot(mpg, aes(x='displ', y='hwy'))
    + geom_point()
    + geom_smooth(span=.3)
    + labs(x='displacement', y='horsepower')
)
```

Plotnine / ggplot2

```
base = alt.Chart(source).mark_circle(
    opacity=0.5
).transform_fold(
    fold=['A', 'B', 'C'],
    as_=['category', 'y']
).encode(
    alt.X('x:Q'),
    alt.Y('y:Q'),
    alt.Color('category:N')
)
```

Altair

```
dict_of_fig = dict({
    "data": [{"type": "bar",
              "x": [1, 2, 3],
              "y": [1, 3, 2]}],
    "layout": {"title":
                    {"text": "My Figure"}}
     })
fig = go.Figure(dict_of_fig)
fig.show()
```

Plotly

Dataviz and intuition

But we don’t have that same kind of intuition for coding charts!

```
fig, ax = plt.subplots()
ax.plot(x, y_est, '-')
ax.fill_between(x,
    y_est - y_err, y_est + y_err,
    alpha=0.2)
```

```
(
    ggplot(mpg, aes(x='displ', y='hwy'))
    + geom_point()
    + geom_smooth(span=.3)
    + labs(x='displacement', y='horsepower')
```

Our intuition for coding is acquired and depends on what we have learnt and understood in the past.

So to find Matplotlib “intuitive” we have to understand how it works!

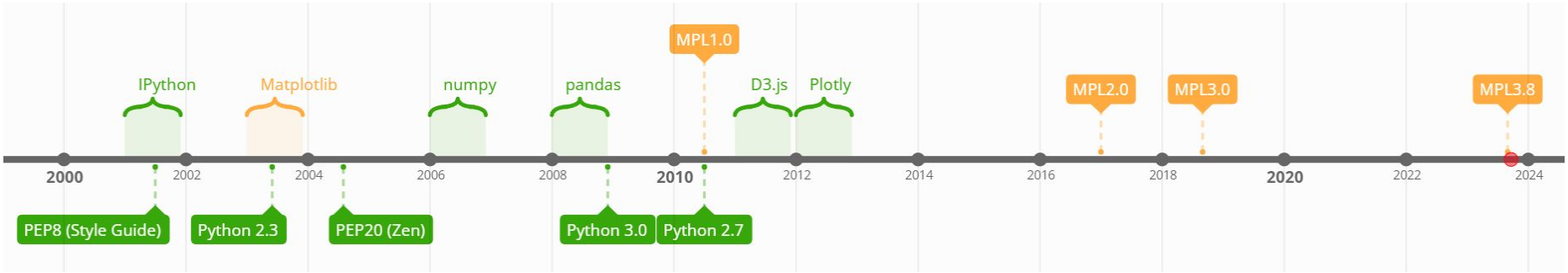
```
).transform_fold(
    fold=['A', 'B', 'C'],
    as_=['category', 'y']
).encode(
    alt.X('x:Q'),
    alt.Y('y:Q'),
    alt.Color('category:N')
)
```

Altair

```
                "x": [1, 2, 3],
                "y": [1, 3, 2]}],
    "layout": {"title":
                    {"text": "My Figure"}}
    })
fig = go.Figure(dict_of_fig)
fig.show()
```

Plotly

20 years is an advantage, but also a disadvantage

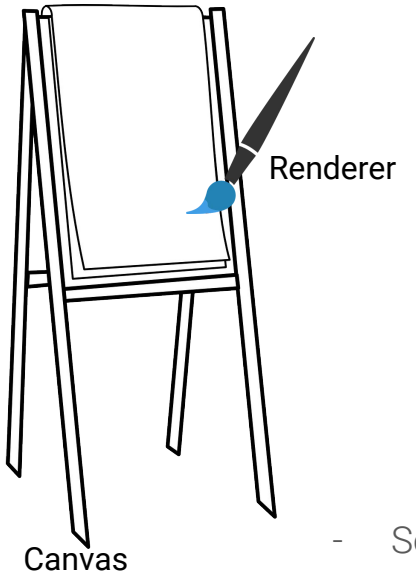


- Matplotlib has been created around 2003 and has undergone few major changes
- It is a mature dataviz library with lots of functionality

- Backward compatibility is very important
- Most of the online teaching material is plagued by legacy code which is discouraged

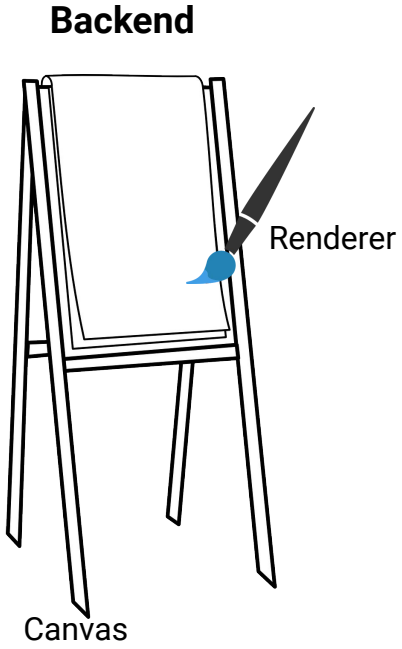
Main guiding idea behind MPL's architecture

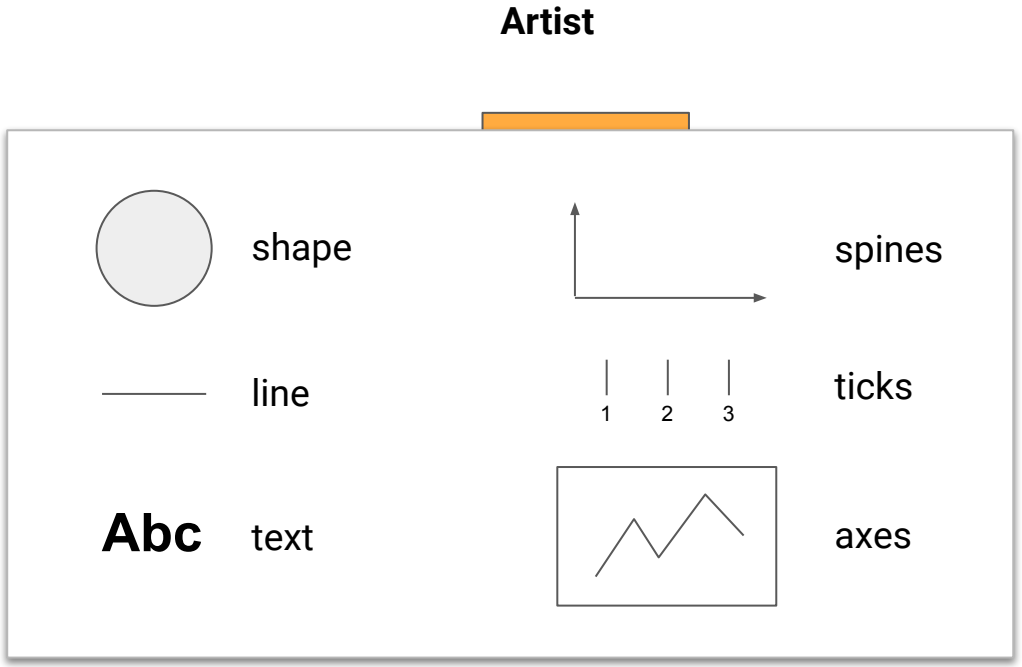
Backend



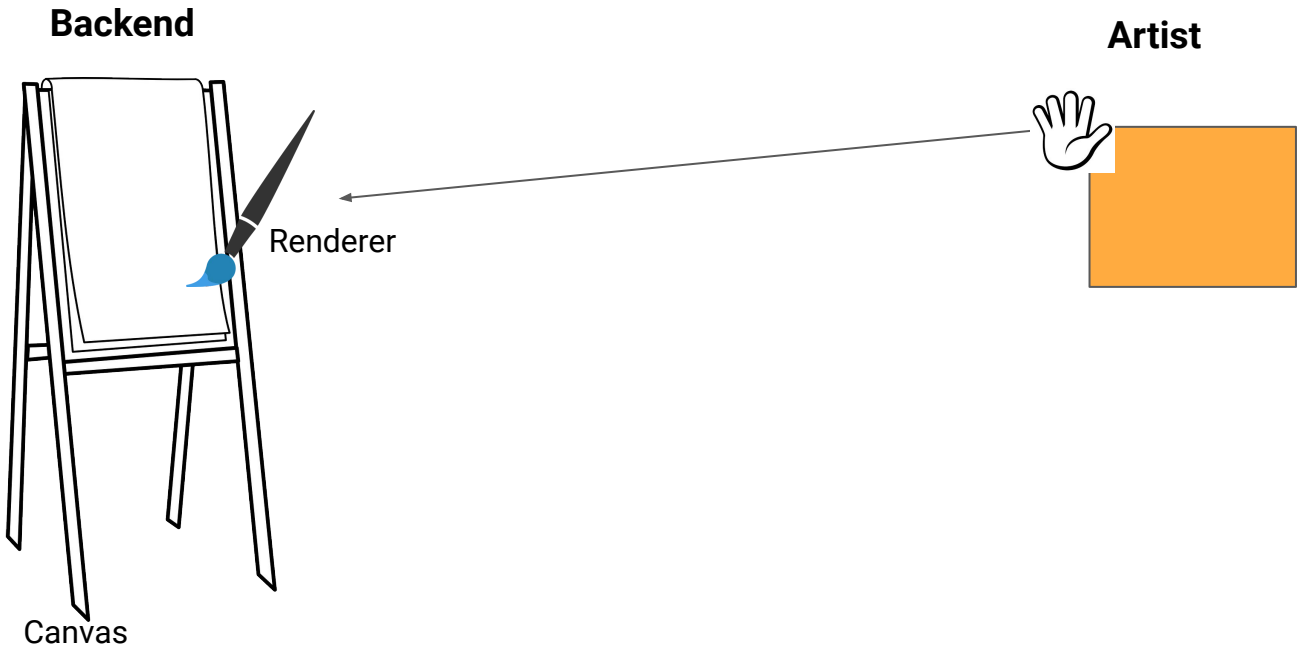
- Something that draws
- Static or interactive, vector or pixel…
- You can write your own backend

Main guiding idea behind MPL's architecture

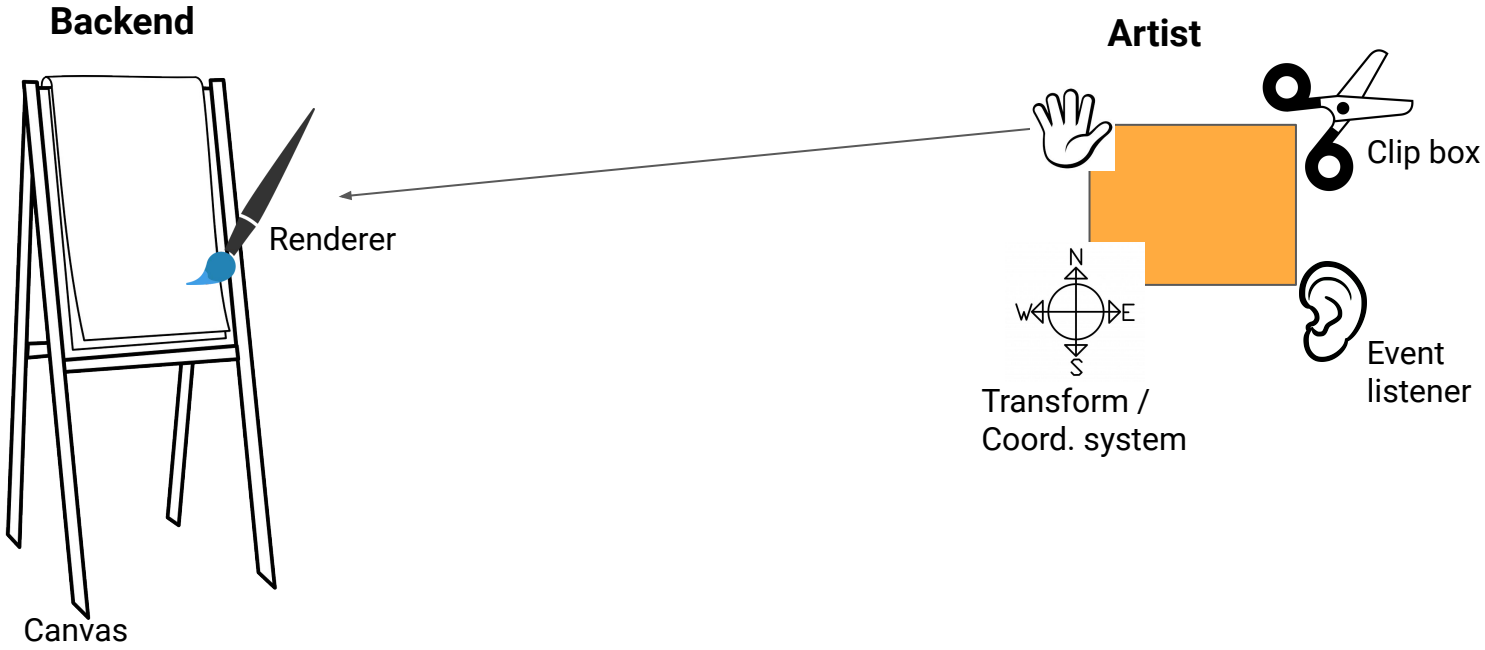




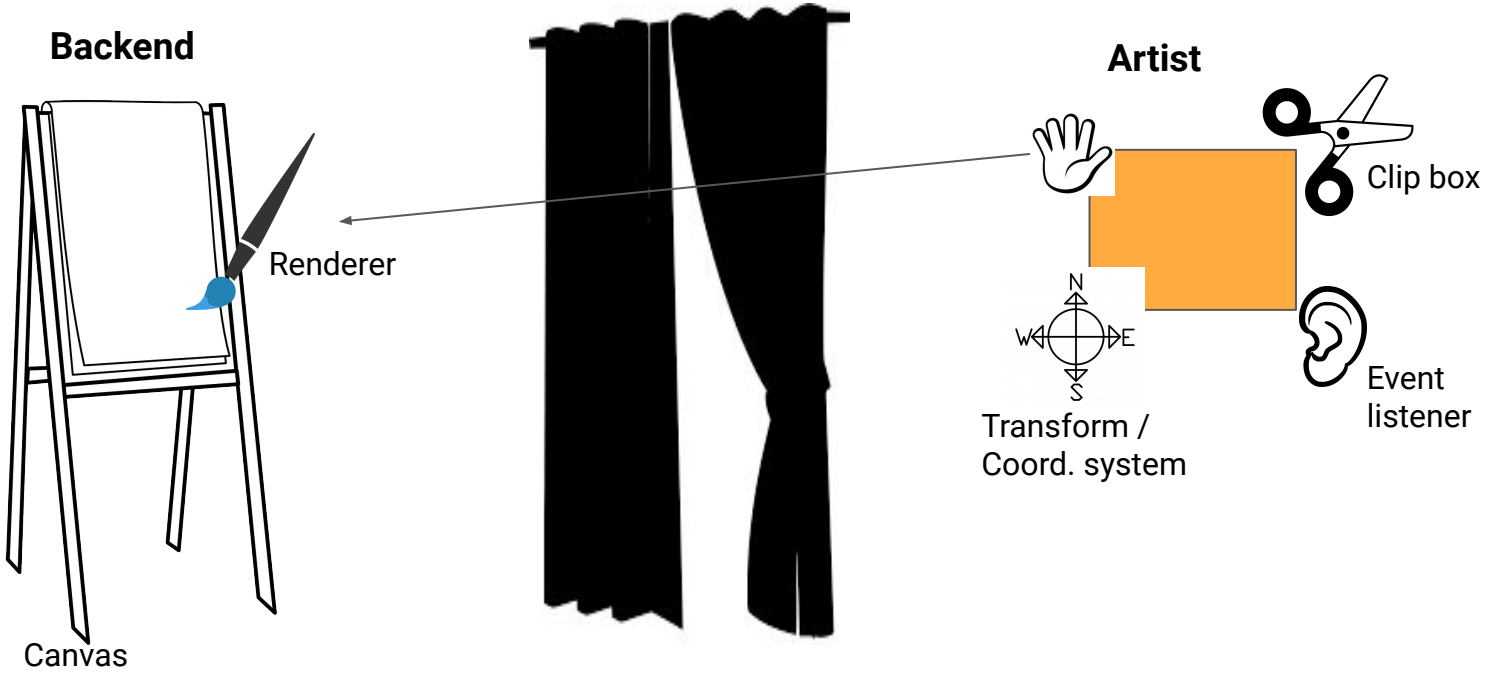
Main guiding idea behind MPL's architecture



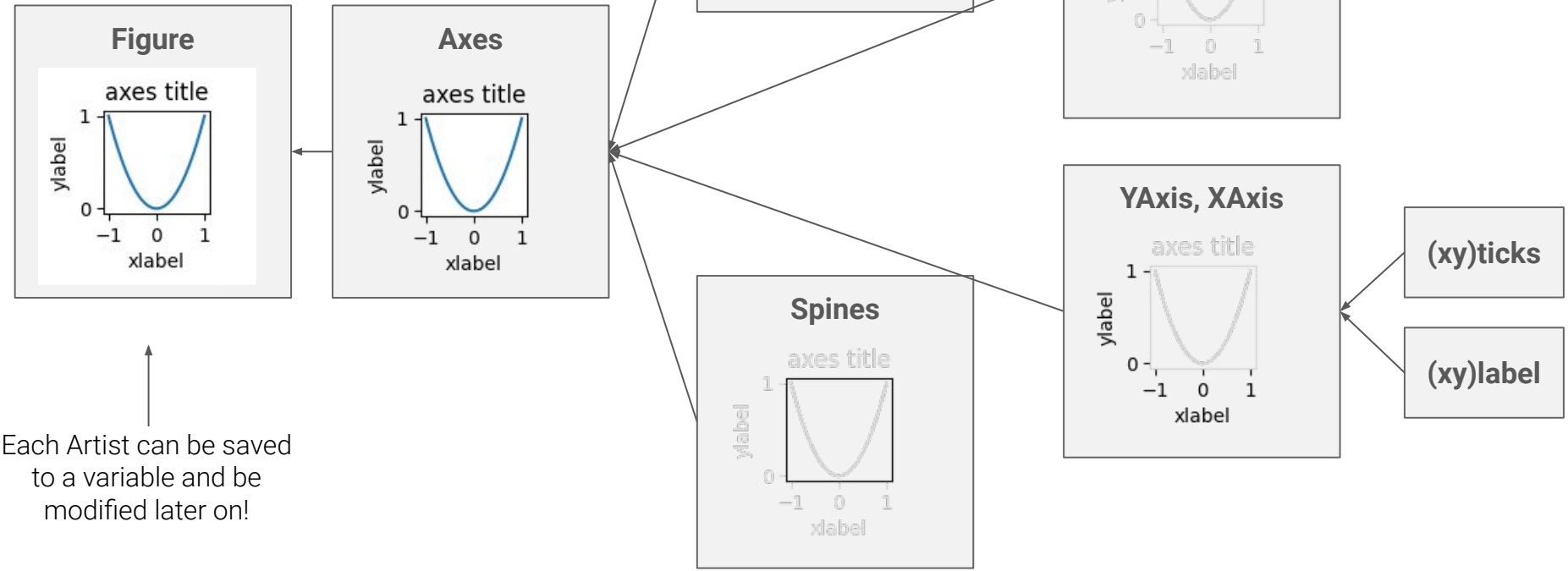
Main guiding idea behind MPL's architecture



Main guiding idea behind MPL's architecture



A graph of Artists



Each Artist can be saved to a variable and be modified later on!

MPL is composed of layers

`ax.{...}`

Artists
chart as a graph of components

Backend
does the actual drawing

But what we typically do is

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

So where is all the PLT-stuff in this model?

`plt.{...}`

Scripting
create and modify groups of artists

`ax.{...}`

Artists
chart as a graph of components

Backend
does the actual drawing

For historical reasons: MATLAB-like functions

```
x = -pi:pi/10:pi;
y = tan(sin(x)) - sin(tan(x));

figure
plot(x,y,'--gs',...
    'LineWidth',2,...
    'MarkerSize',10,...
    'MarkerEdgeColor','b',...
    'MarkerFaceColor',[0.5,0.5,0.5])
title('2-D Line Plot')
xlabel('x')
ylabel('y')
```

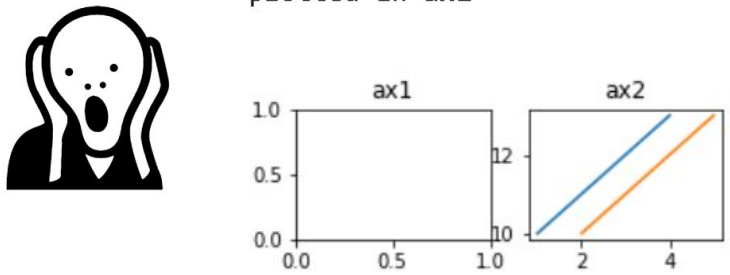
Matlab

PLT-API (MATLAB-API) is **evil**!
It tries to guess what is the latest active object.

```
x = np.array([1, 2, 3, 4])
y = np.array([10, 11, 12, 13])
```

```
f, axes = plt.subplots(ncols=2, figsize=(4,1.25))
axes[0].set_title('ax1')
axes[1].set_title('ax2')

for i,ax in enumerate(axes):
    plt.plot(x+i,y)
    print('plotted in {}'.format(ax.get_title()))
```

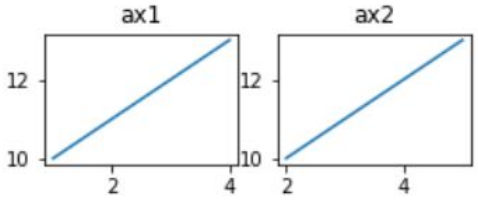
```
plotted in ax1
plotted in ax2
```



PLT / MATLAB / implicit API

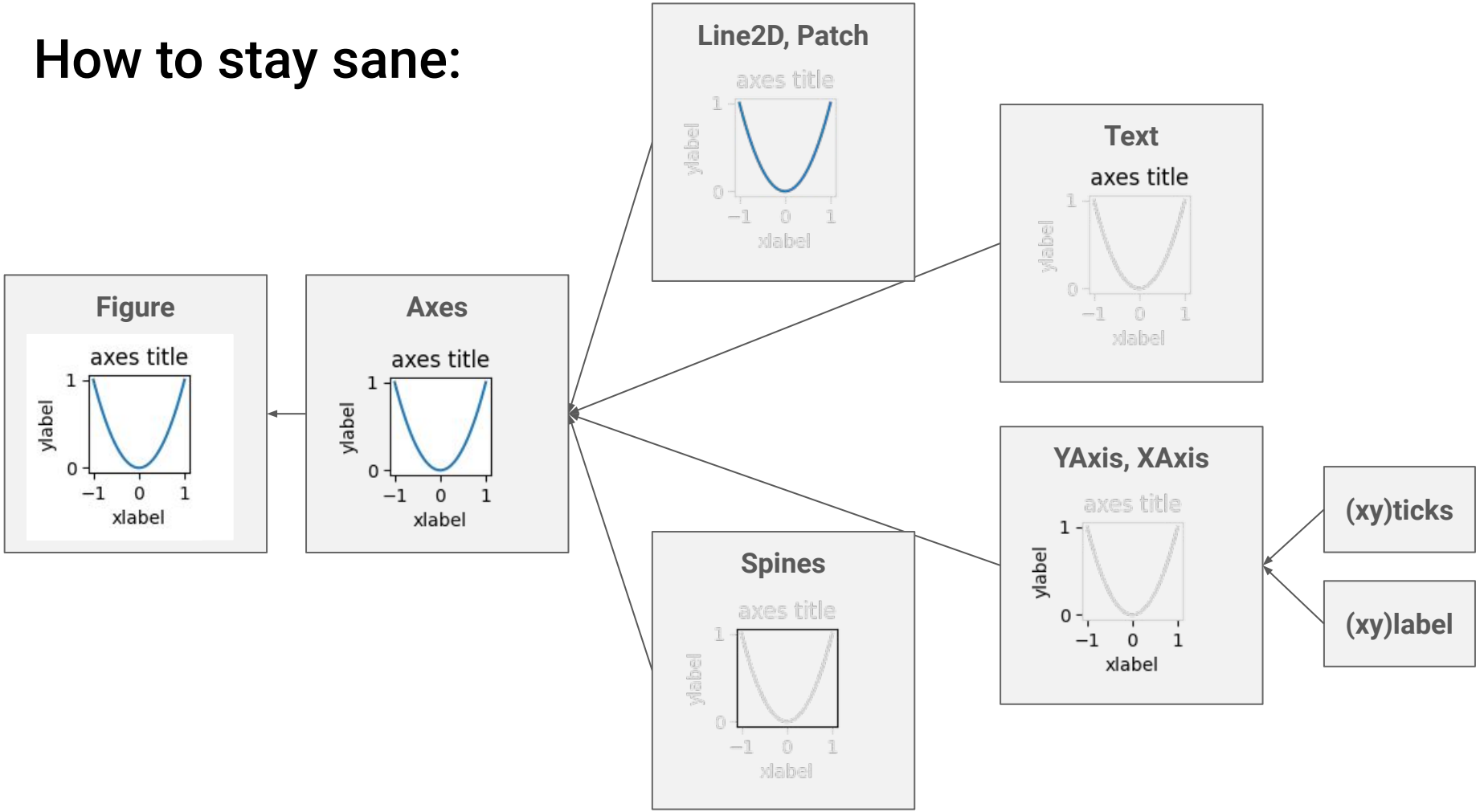
```
f, axes = plt.subplots(ncols=2, figsize=(4,1.25))
axes[0].set_title('ax1')
axes[1].set_title('ax2')

for i,ax in enumerate(axes):
    ax.plot(x+i,y)
    print('plotted in {}'.format(ax.get_title()))
```

```
plotted in ax1
plotted in ax2
```



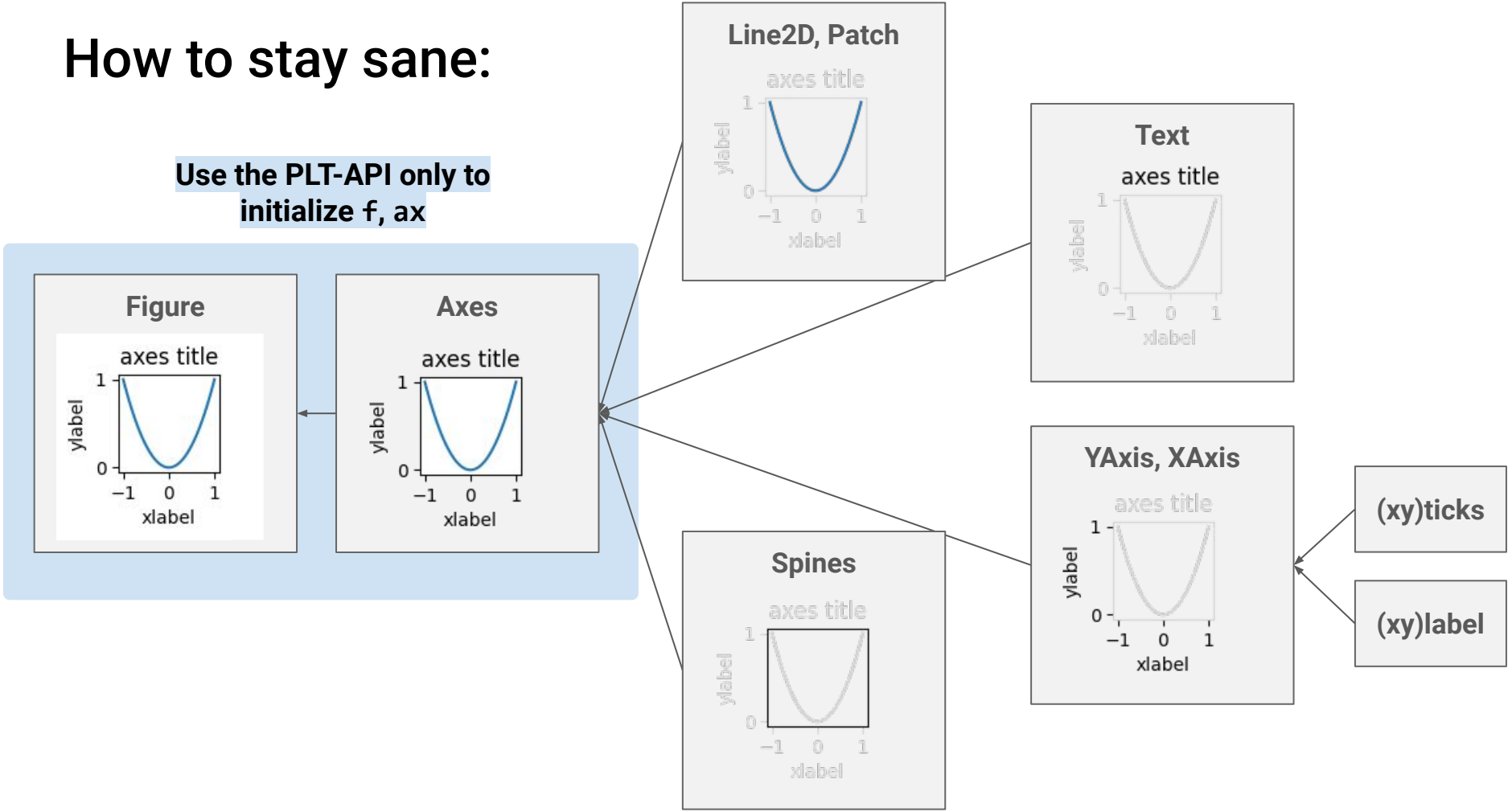
object-oriented / explicit API

How to stay sane:



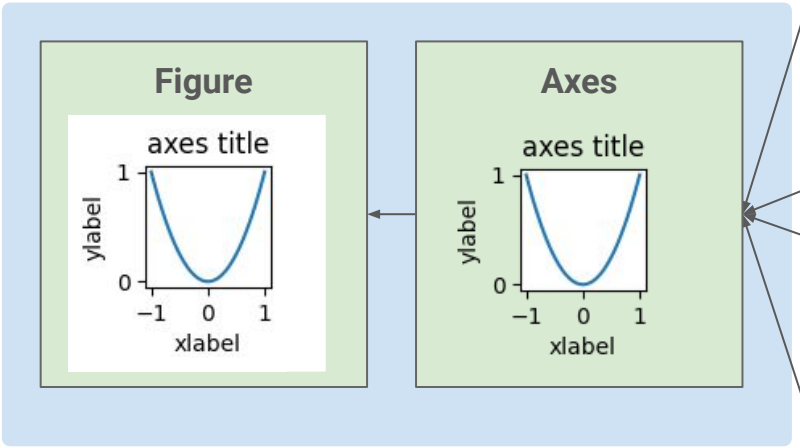
How to stay sane:

Use the PLT-API only to initialize `f`, `ax`

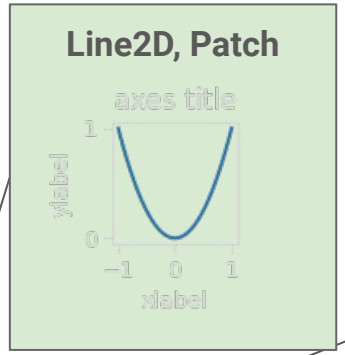


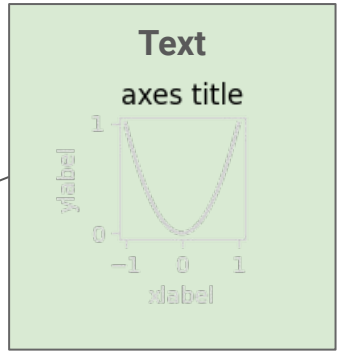
How to stay sane:

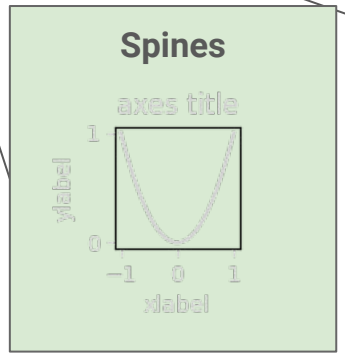
Use the PLT-API only to initialize `f`, `ax`

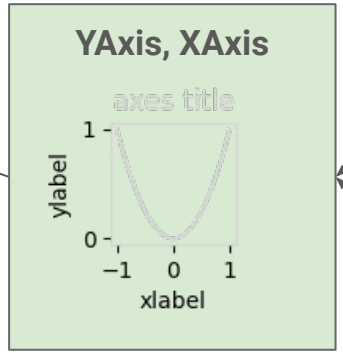


Use the OO-API to do everything else with `f`, `ax` and other objects directly







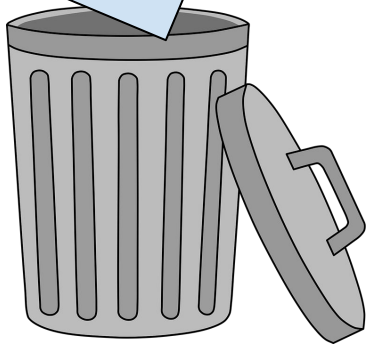


(xy)ticks

(xy)label

`plt.{...}`

Scripting
create and modify groups of artists



`ax.{...}`

Artists
chart as a graph of components

`plt.{layout}`

Backend
does the actual drawing

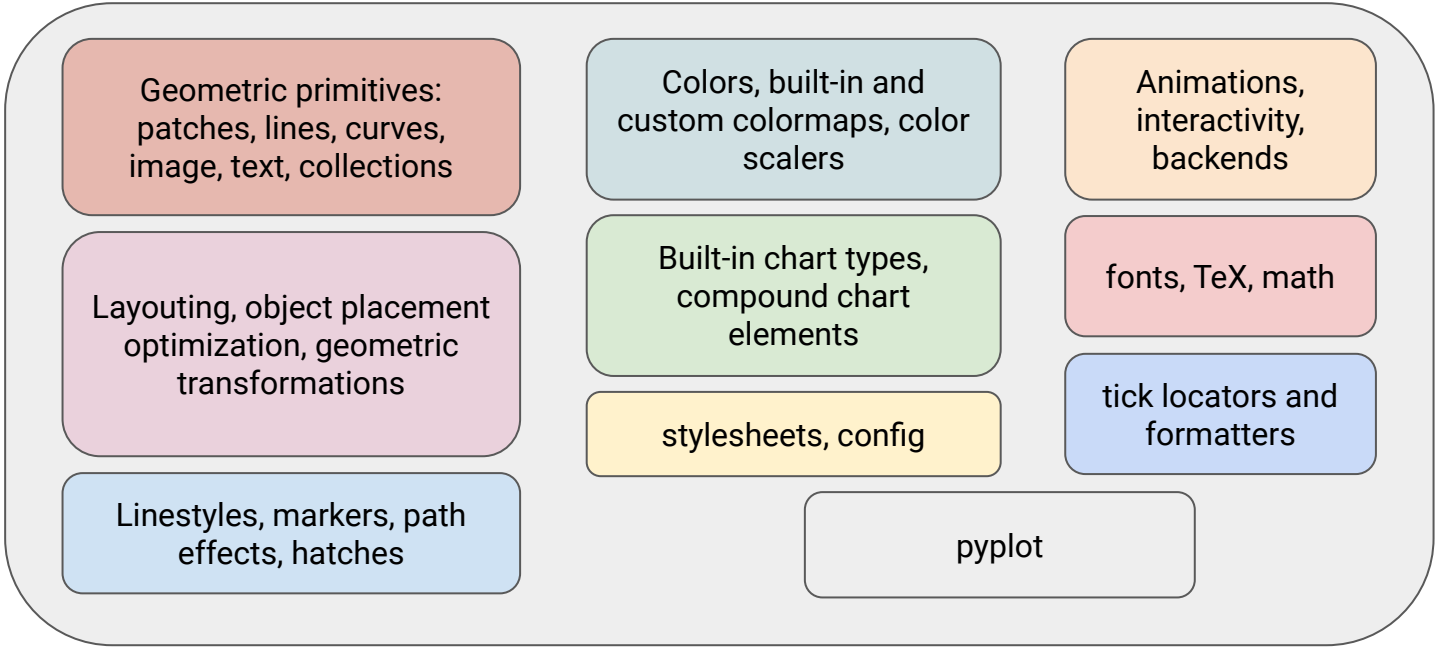
2: The awesome parts

`matplotlib.pyplot` is a tip of the iceberg

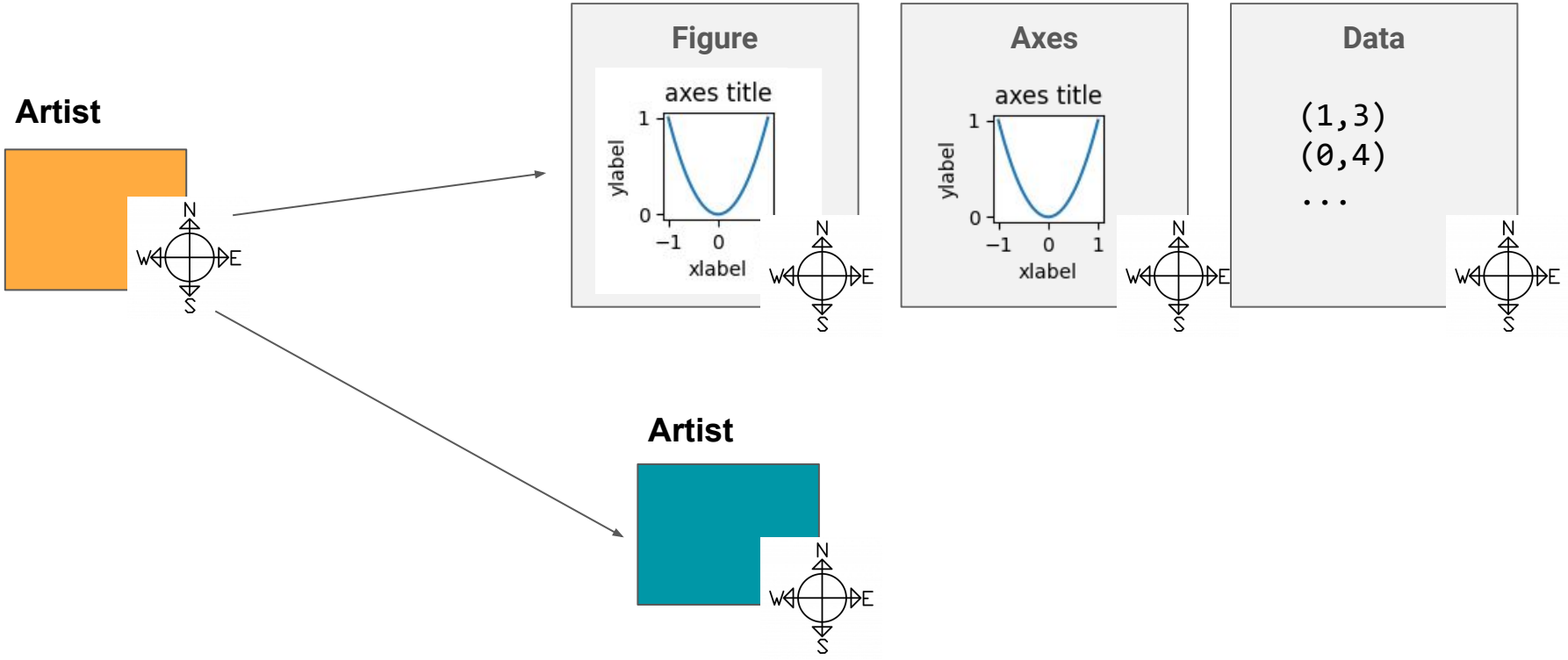
```
import matplotlib.pyplot as plt
```

`matplotlib.pyplot` is a tip of the iceberg

```
import matplotlib.pyplot as plt
from matplotlib.{...} import {...}
```

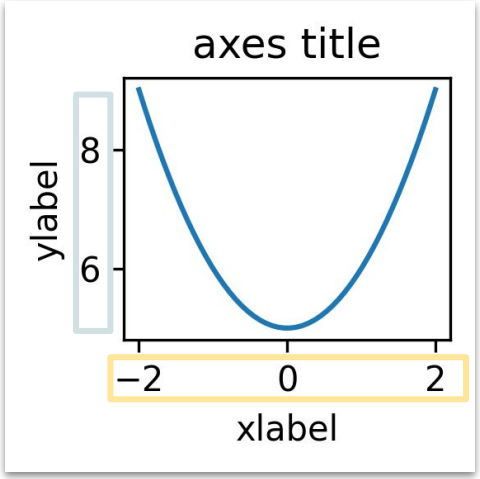


Coordinate systems



Coordinate systems

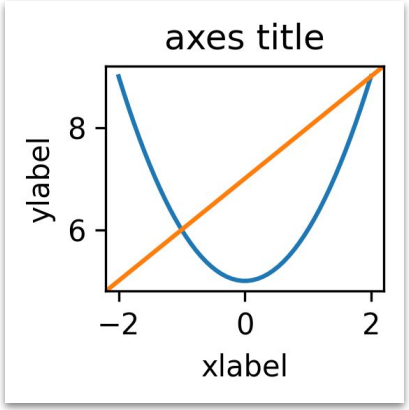
```
def example_plot(plot_kws = {}):
    x = np.linspace(-2,2,) # -2..2
    y = x**2+5 # 5..9
    f, ax = plt.subplots(figsize=(2,2), layout='tight')
    ax.plot(x, y, **plot_kws)
    ax.set_title('axes title')
    ax.set_xlabel('xlabel')
    ax.set_ylabel('ylabel')
    return f, ax

f, ax = example_plot()
```



Coordinate systems

```
f, ax = example_plot()
ax.plot([0, 1], [0, 1],
        transform=ax.transAxes)
```

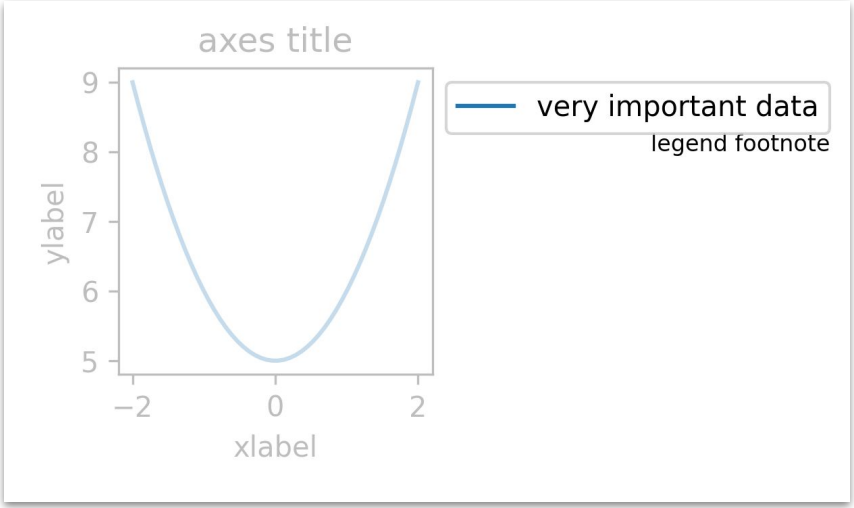
Plot an additional line from 0% to 100% of the extents of the **ax** on both x and y axis. Useful for watermarks, guiding lines etc.



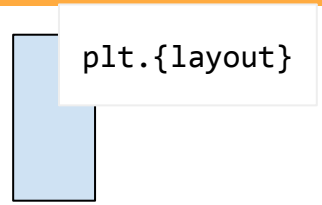
Coordinate systems

```
f, ax = example_plot_with_blur()
legend_object = ax.legend(bbox_to_anchor=[1,1])
legend_footnote = ax.annotate(
    text='legend footnote', fontsize=8,
    xy=[1,0], xycoords=legend_object,
    va='top', ha='right'
    )
```

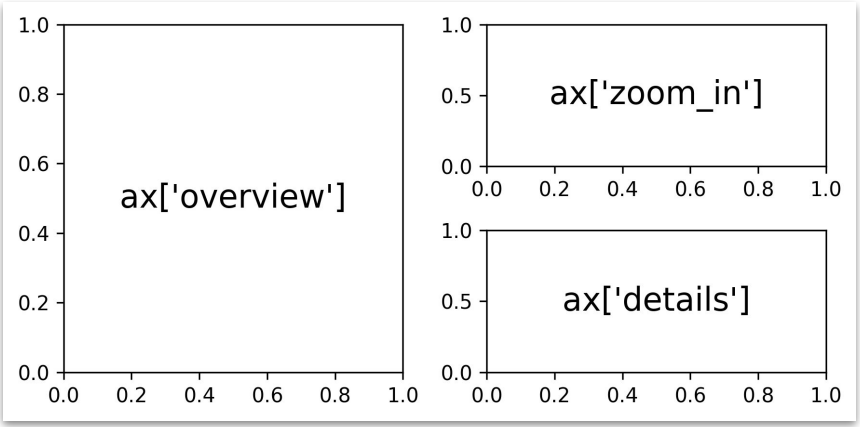
Anchor the top-right corner of the `legend_footnote` to the point on the chart where the `legend_object` has 100% of its width and 0% of its height



Clever layouting: `subplot_mosaic`




```
f, ax = plt.subplot_mosaic(
    mosaic = [['overview', 'zoom_in'],
              ['overview', 'details']],
    figsize=(6,3), layout='tight'
    )

for k in ['overview', 'zoom_in', 'details']:
    ax[k].text(s=f"ax['{k}']",
        x=0.5, y=0.5,
        ha='center', va='center',
        fontproperties={'size':16})
```

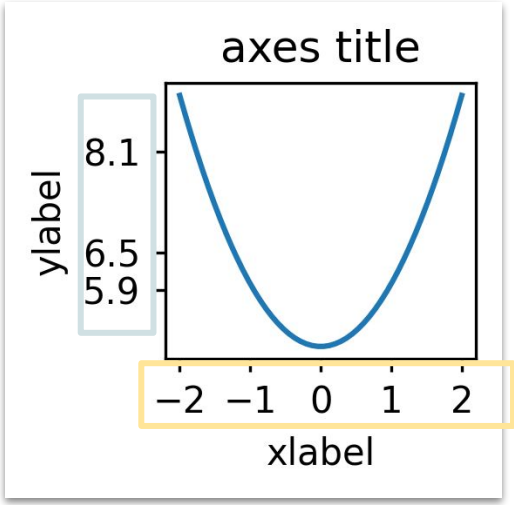


Create layouts using arrays of keys, which are then used to address a particular axes of a figure

Effortless tick positions

`matplotlib.ticker` contains in-built tick generators:

```
from matplotlib.ticker import MultipleLocator, FixedLocator

f, ax = example_plot()

ax.xaxis.set_major_locator(MultipleLocator(1))
ax.yaxis.set_major_locator(FixedLocator([5.9, 6.5, 8.1]))
```

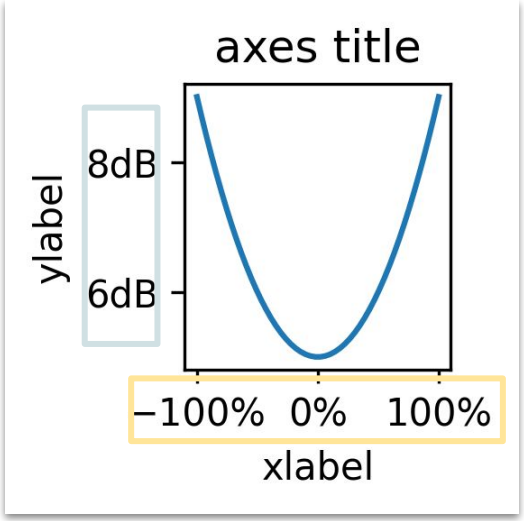


Tick location generator can be attached to the each Spine independently.

Effortless tick label formatting

```
from matplotlib.ticker import PercentFormatter, StrMethodFormatter

f, ax = example_plot()

ax.xaxis.set_major_formatter(PercentFormatter(xmax=2))
ax.yaxis.set_major_formatter(StrMethodFormatter('{x:.0f}dB'))
```

Similarly, attach a pre-built or completely custom string formatting function that should be applied for each tick label on a Spine.

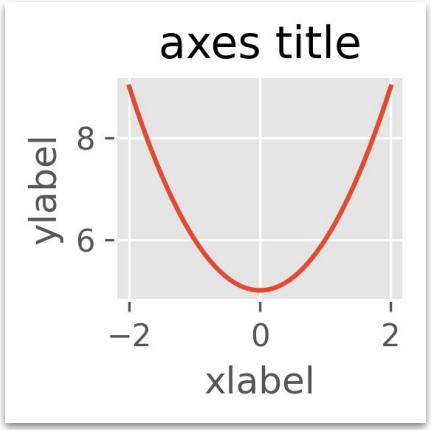


Stylesheets

```
import matplotlib as mpl
```

```
mpl.style.use('ggplot')
example_plot()
```

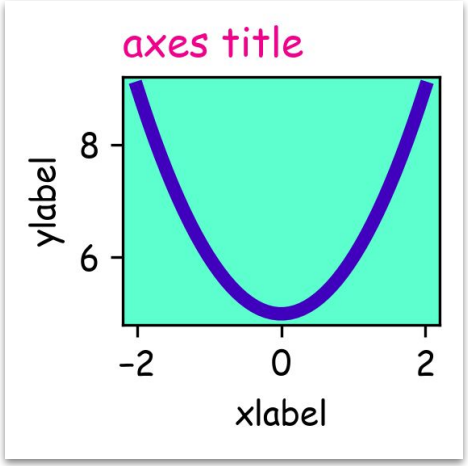
```
with mpl.style.context('ggplot'):
    example_plot()
```



Matplotlib lets you store chart styling in stylesheets. It comes with a set of in-built stylesheets which you can apply for the whole session or in the context of one figure only.

Stylesheets

```
import matplotlib as mpl
from cycler import cycler

with mpl.rc_context({'lines.linewidth': 4,
                     'axes.prop_cycle': cycler('color', ['#4200bf']),
                     'axes.facecolor': '#5effcf',
                     'axes.titlelocation': 'left',
                     'axes.titlecolor': '#ef028c',
                     'font.family': 'Comic Sans MS'}):
    example_plot()
```



You can also define your own stylesheet as a dictionary or store it in a configuration file.

3: Viz as code

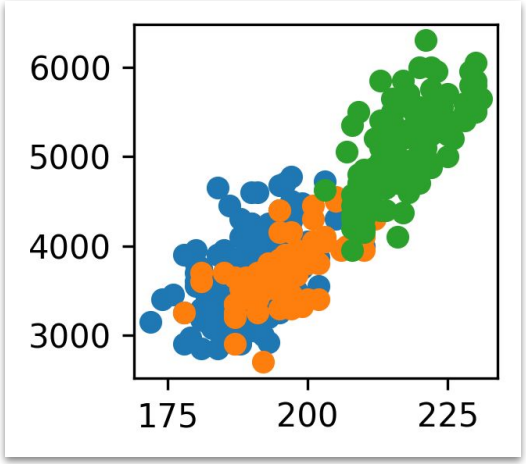
Example data

```
import seaborn as sns
data = sns.load_dataset('penguins')
data.sample(5)
```

	species	island	bill_length_mm	bill_depth_mm	flipper_length_mm	body_mass_g	sex
171	Chinstrap	Dream	49.2	18.2	195.0	4400.0	Male
310	Gentoo	Biscoe	47.5	15.0	218.0	4950.0	Female
211	Chinstrap	Dream	45.6	19.4	194.0	3525.0	Female
15	Adelie	Torgersen	36.6	17.8	185.0	3700.0	Female
96	Adelie	Dream	38.1	18.6	190.0	3700.0	Female

Use loops

```
f, ax = plt.subplots(figsize=(2,2))

for chosen in data['species'].unique():
    tmp_data = data.query('species == @chosen')
    ax.scatter(x=tmp_data['flipper_length_mm'],
               y=tmp_data['body_mass_g'])
```

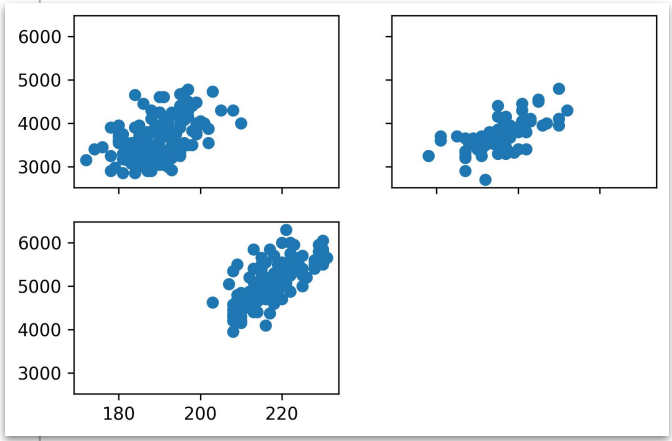


You can overplot many plot types in the same axes.
MPL will use a default cycler to change their visual properties.

If you cycle over subsets of your data, don't hardcode it!
Use loops.

Use `zip` and `zip_longest`

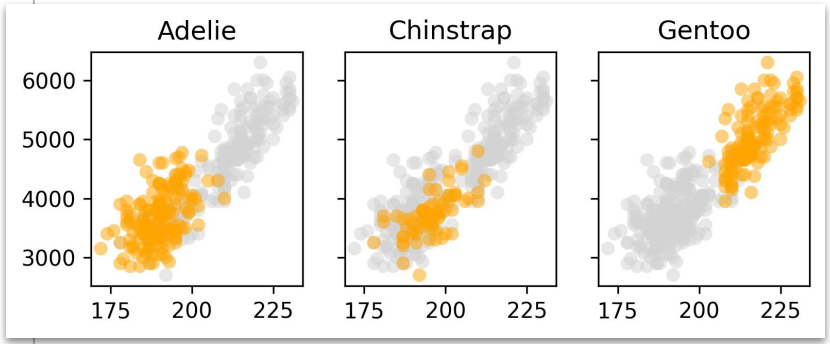
```
from itertools import zip_longest

f, axes = plt.subplots(ncols=2, nrows=2,
                       sharex=True, sharey=True,
                      figsize=(6,4), squeeze=False)

for chosen, ax in zip_longest(data['species'].unique(), axes.ravel()):
    if chosen is not None:
        tmp_data = data.query('species == @chosen')
        ax.scatter(
            x=tmp_data['flipper_length_mm'],
            y=tmp_data['body_mass_g'])
    else:
        ax.remove()
```



`axes` returned by **`plt.subplots`** are a numpy array. To plot a subset of data on each subplot, use loops together with **`zip`** and/or **`zip_longest`**.

Use dictionaries for styling

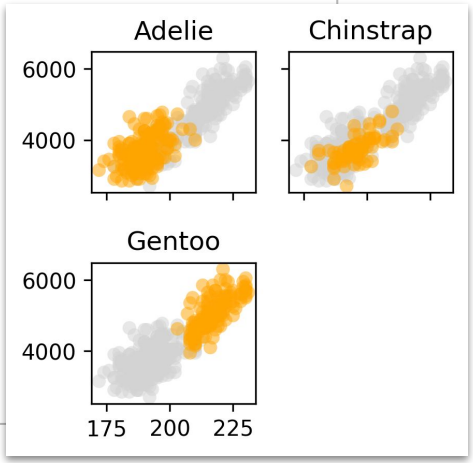
```
f, axes = plt.subplots(ncols=3, nrows=1,
                       sharex=True, sharey=True,
                       figsize=(6,2),)

selected = {'color': 'orange'}
background = {'color': 'lightgray'}
shared_style = {'alpha': 0.5, 's': 40, 'edgecolors': 'none'}

for chosen, ax in zip(data['species'].unique(), axes.ravel()):
    tmp_data = data.query('species == @chosen')
    bg_data = data.query('species != @chosen')
    ax.scatter(x=bg_data['flipper_length_mm'],
               y=bg_data['body_mass_g'],
               **background, **shared_style)
    ax.scatter(x=tmp_data['flipper_length_mm'],
               y=tmp_data['body_mass_g'],
               **selected, **shared_style)
    ax.set_title(chosen)
```



Don’t hardcode the style of your charts either! Make your code reusable and sustainable by storing such configuration in dictionaries.

Structure your code

```python
def plot_single(data, chosen, ax, selected={}, background={}, plot_kws={}):
    tmp_data, bg_data = data.query('species == @chosen'), data.query('species != @chosen')
    ax.scatter(x=bg_data['flipper_length_mm'], y=bg_data['body_mass_g'], **background, **plot_kws)
    ax.scatter(x=tmp_data['flipper_length_mm'], y=tmp_data['body_mass_g'], **selected, **plot_kws)
    ax.set_title(chosen)

def dashboard(data, selected, background, dashboard_kws={}, plot_kws={}):
    f, axes = plt.subplots(ncols=2, nrows=2, sharex=True, sharey=True, dpi=200, **dashboard_kws)
    for chosen, ax in zip_longest(data['species'].unique(), axes.ravel()):
        if chosen is not None:
            plot_single(data=data, chosen=chosen, ax=ax,
                        selected=selected, background=background, plot_kws=plot_kws)
        else:
            ax.remove()
    return f, axes

selected = {'color': 'orange'}
background = {'color': 'lightgray'}
shared_style = {'alpha': 0.5, 's': 40, 'edgecolors': 'none'}
f, axes = dashboard(data, selected=selected, background=background,
                    dashboard_kws={'figsize': (3,3), 'gridspec_kw': {'hspace': 0.5}},
                    plot_kws=shared_style)
```

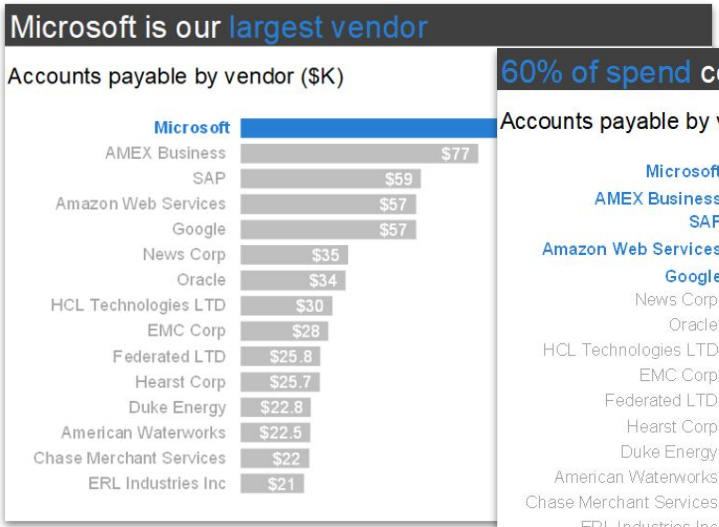


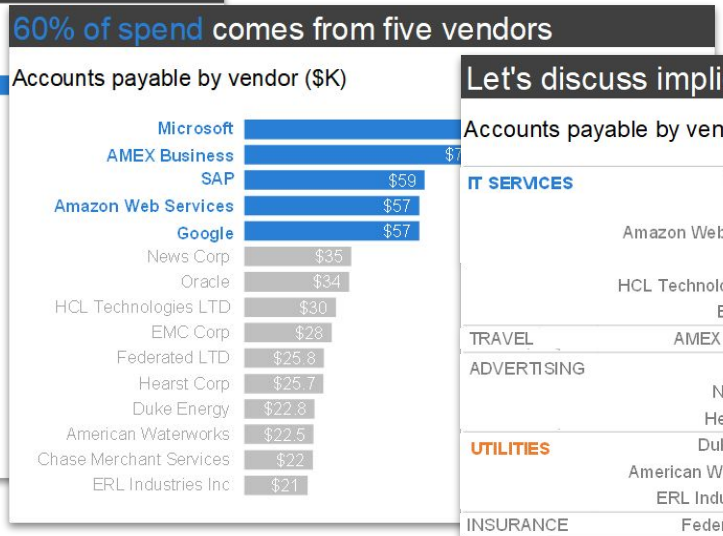
*this is not a production-ready code! Watch out for dangerous default values

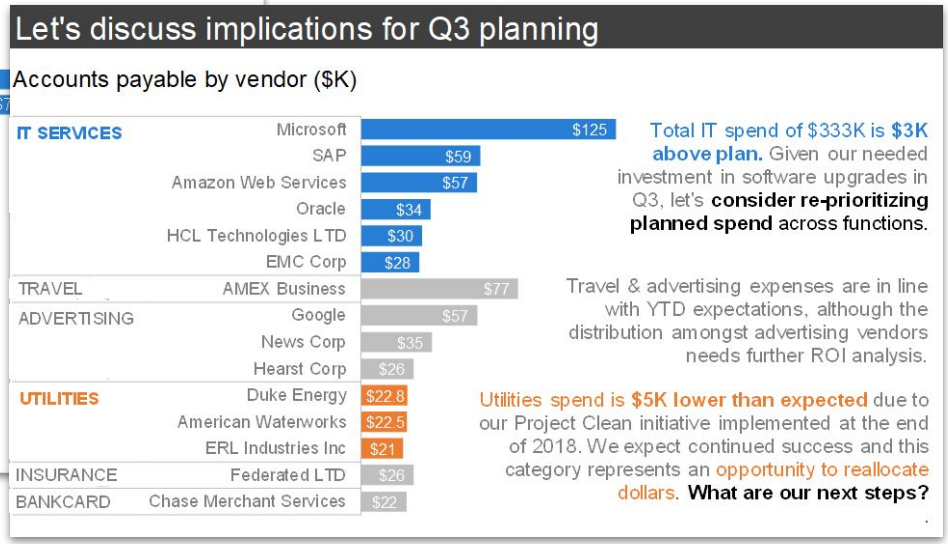
4: How to design better charts

Don’t let the software decide for you

- Visualization is communication, and a bar chart != bar chart.
- Never rely on the software defaults to shape your message. Own the design of your visualization and apply it intentionally.

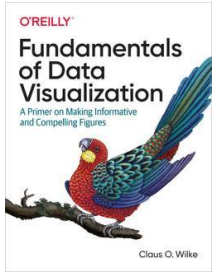






https://www.storytellingwithdata.com/blog/2019/7/10/power-pairing-color-words

Some resources to get better at dataviz

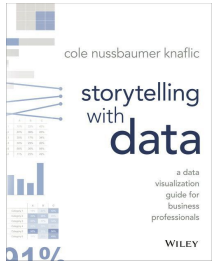


https://clauswilke.com/dataviz

Datawrapper | Blog

https://blog.datawrapper.de

https://github.com/rougier/scientific-visualization-book



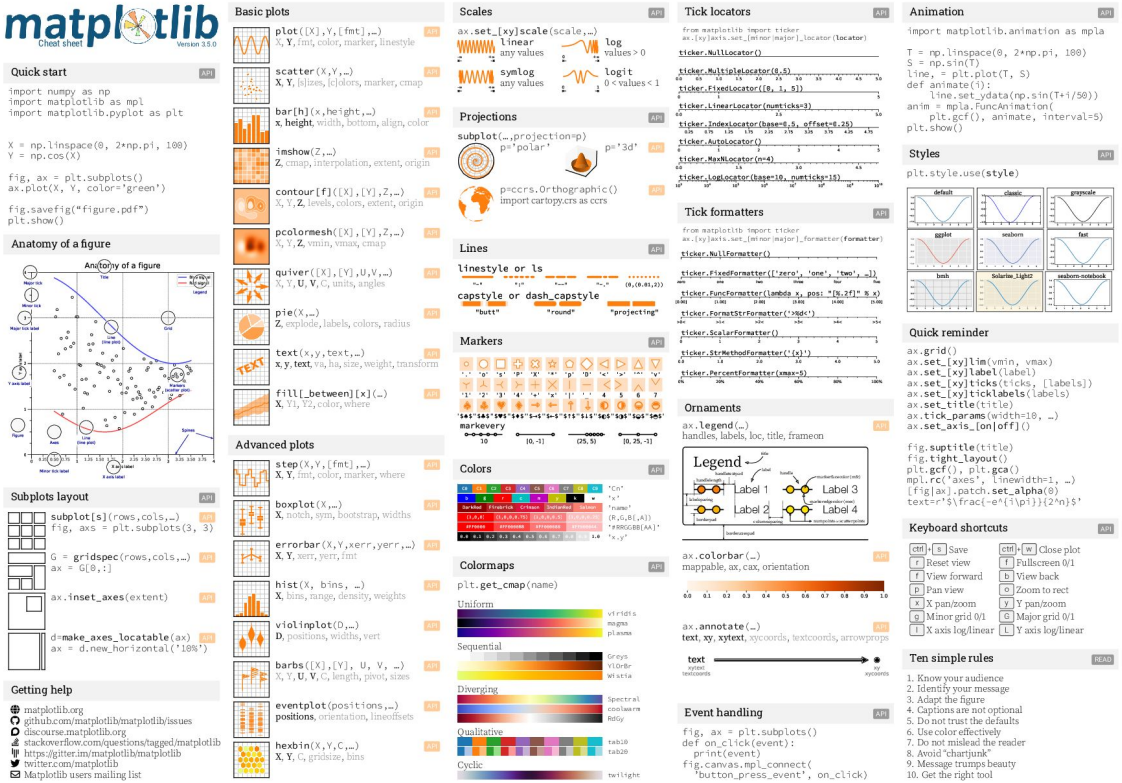
https://www.storytellingwithdata.com

paniterka / awesome-matplotlib

https://github.com/paniterka/awesome-matplotlib

MPL cheatsheets and handouts

https://matplotlib.org/cheatsheets/



Matplotlib needs you!

- Documentation is constantly being improved, and there are many new projects going on
- Sneak peek: https://matplotlib.org/devdocs/
- Fresh eyes are always the best for improving the docs! Let me know if you are interested to contribute

Thank you!

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