

Note that by default, the text is aligned above and to the left of the specified coordinates; here the “.” at the beginning of each string will approximately mark the given coordinate location.

The `transData` coordinates give the usual data coordinates associated with the x- and y-axis labels. The `transAxes` coordinates give the location from the bottom-left corner of the axes (here the white box) as a fraction of the axes size. The `transFigure` coordinates are similar, but specify the position from the bottom left of the figure (here the gray box) as a fraction of the figure size.

Notice now that if we change the axes limits, it is only the `transData` coordinates that will be affected, while the others remain stationary (Figure 4-70):

```
In[6]: ax.set_xlim(0, 2)
       ax.set_ylim(-6, 6)
       fig
```

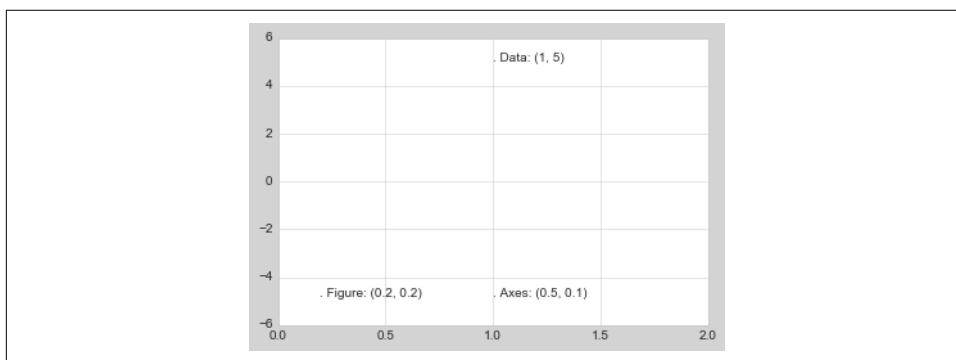


Figure 4-70. Comparing Matplotlib’s coordinate systems

You can see this behavior more clearly by changing the axes limits interactively; if you are executing this code in a notebook, you can make that happen by changing `%matplotlib inline` to `%matplotlib notebook` and using each plot’s menu to interact with the plot.

Arrows and Annotation

Along with tick marks and text, another useful annotation mark is the simple arrow.

Drawing arrows in Matplotlib is often much harder than you might hope. While there is a `plt.arrow()` function available, I wouldn’t suggest using it; the arrows it creates are SVG objects that will be subject to the varying aspect ratio of your plots, and the result is rarely what the user intended. Instead, I’d suggest using the `plt.annotate()` function. This function creates some text and an arrow, and the arrows can be very flexibly specified.

Here we'll use `annotate` with several of its options (Figure 4-71):

```
In[7]: %matplotlib inline

fig, ax = plt.subplots()

x = np.linspace(0, 20, 1000)
ax.plot(x, np.cos(x))
ax.axis('equal')

ax.annotate('local maximum', xy=(6.28, 1), xytext=(10, 4),
           arrowprops=dict(facecolor='black', shrink=0.05))

ax.annotate('local minimum', xy=(5 * np.pi, -1), xytext=(2, -6),
           arrowprops=dict(arrowstyle="->",
                           connectionstyle="angle3,angleA=0,angleB=-90"));
```

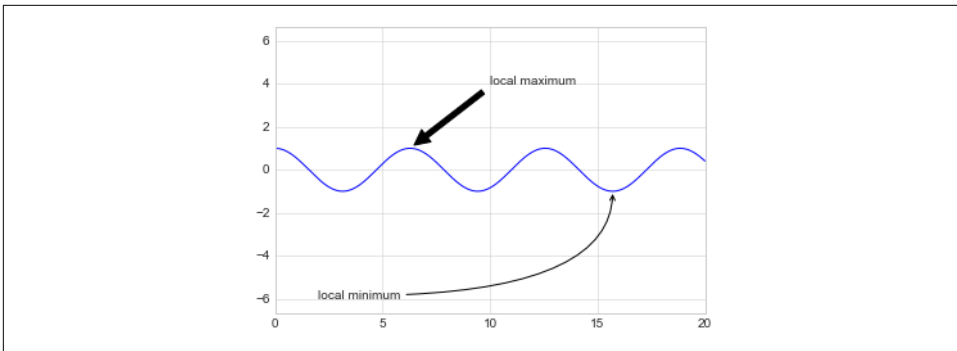


Figure 4-71. Annotation examples

The arrow style is controlled through the `arrowprops` dictionary, which has numerous options available. These options are fairly well documented in Matplotlib's online documentation, so rather than repeating them here I'll quickly show some of the possibilities. Let's demonstrate several of the possible options using the birthrate plot from before (Figure 4-72):

```
In[8]:
fig, ax = plt.subplots(figsize=(12, 4))
births_by_date.plot(ax=ax)

# Add labels to the plot
ax.annotate("New Year's Day", xy=('2012-1-1', 4100), xycoords='data',
           xytext=(50, -30), textcoords='offset points',
           arrowprops=dict(arrowstyle="->",
                           connectionstyle="arc3,rad=-0.2"))

ax.annotate("Independence Day", xy=('2012-7-4', 4250), xycoords='data',
           bbox=dict(boxstyle="round", fc="none", ec="gray"),
```

```

        xytext=(10, -40), textcoords='offset points', ha='center',
        arrowprops=dict(arrowstyle="->"))

ax.annotate('Labor Day', xy=('2012-9-4', 4850), xycoords='data', ha='center',
            xytext=(0, -20), textcoords='offset points')
ax.annotate('', xy=('2012-9-1', 4850), xytext=('2012-9-7', 4850),
            xycoords='data', textcoords='data',
            arrowprops={'arrowstyle': '|-|',widthA=0.2,widthB=0.2', })

ax.annotate('Halloween', xy=('2012-10-31', 4600), xycoords='data',
            xytext=(-80, -40), textcoords='offset points',
            arrowprops=dict(arrowstyle="fancy",
                            fc="0.6", ec="none",
                            connectionstyle="angle3,angleA=0,angleB=-90"))

ax.annotate('Thanksgiving', xy=('2012-11-25', 4500), xycoords='data',
            xytext=(-120, -60), textcoords='offset points',
            bbox=dict(boxstyle="round4,pad=.5", fc="0.9"),
            arrowprops=dict(arrowstyle="->",
                            connectionstyle="angle,angleA=0,angleB=80,rad=20"))

ax.annotate('Christmas', xy=('2012-12-25', 3850), xycoords='data',
            xytext=(-30, 0), textcoords='offset points',
            size=13, ha='right', va="center",
            bbox=dict(boxstyle="round", alpha=0.1),
            arrowprops=dict(arrowstyle="wedge,tail_width=0.5", alpha=0.1));

# Label the axes
ax.set(title='USA births by day of year (1969-1988)',
       ylabel='average daily births')

# Format the x axis with centered month labels
ax.xaxis.set_major_locator(mpl.dates.MonthLocator())
ax.xaxis.set_minor_locator(mpl.dates.MonthLocator(bymonthday=15))
ax.xaxis.set_major_formatter(plt.NullFormatter())
ax.xaxis.set_minor_formatter(mpl.dates.DateFormatter('%h'));

ax.set_ylim(3600, 5400);

```

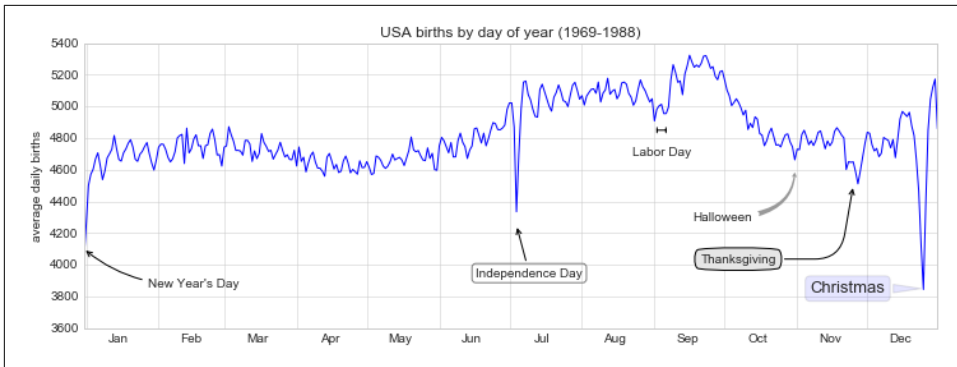


Figure 4-72. Annotated average birth rates by day

You'll notice that the specifications of the arrows and text boxes are very detailed: this gives you the power to create nearly any arrow style you wish. Unfortunately, it also means that these sorts of features often must be manually tweaked, a process that can be very time-consuming when one is producing publication-quality graphics! Finally, I'll note that the preceding mix of styles is by no means best practice for presenting data, but rather included as a demonstration of some of the available options.

More discussion and examples of available arrow and annotation styles can be found in the Matplotlib gallery, in particular http://matplotlib.org/examples/pylab_examples/annotation_demo2.html.

Customizing Ticks

Matplotlib's default tick locators and formatters are designed to be generally sufficient in many common situations, but are in no way optimal for every plot. This section will give several examples of adjusting the tick locations and formatting for the particular plot type you're interested in.

Before we go into examples, it will be best for us to understand further the object hierarchy of Matplotlib plots. Matplotlib aims to have a Python object representing everything that appears on the plot: for example, recall that the `figure` is the bounding box within which plot elements appear. Each Matplotlib object can also act as a container of sub-objects; for example, each `figure` can contain one or more axes objects, each of which in turn contain other objects representing plot contents.

The tick marks are no exception. Each `axes` has attributes `xaxis` and `yaxis`, which in turn have attributes that contain all the properties of the lines, ticks, and labels that make up the axes.