Multiple Subplots

Sometimes it is helpful to compare different views of data **side by side.**

To this end, Matplotlib has the concept of **subplots**: groups of smaller axes that can exist together within a single figure.

These **subplots** might be insets, grids of plots, or other more complicated layouts.

In [ ]:

```
%matplotlib inline
import matplotlib.pyplot as plt
plt.style.use('seaborn-white')
import numpy as np
```

plt.axes: Subplots by Hand

The most basic method of creating an axes is to use the `plt.axes` function.

As we've seen previously, by default this creates a standard axes object that fills the entire figure.

`plt.axes` also takes an **optional argument** that is a list of four numbers in the figure coordinate system (`[left, bottom, width, height]`),

which ranges from 0 at the **bottom left** of the figure to 1 at the **top right** of the figure.

For example,

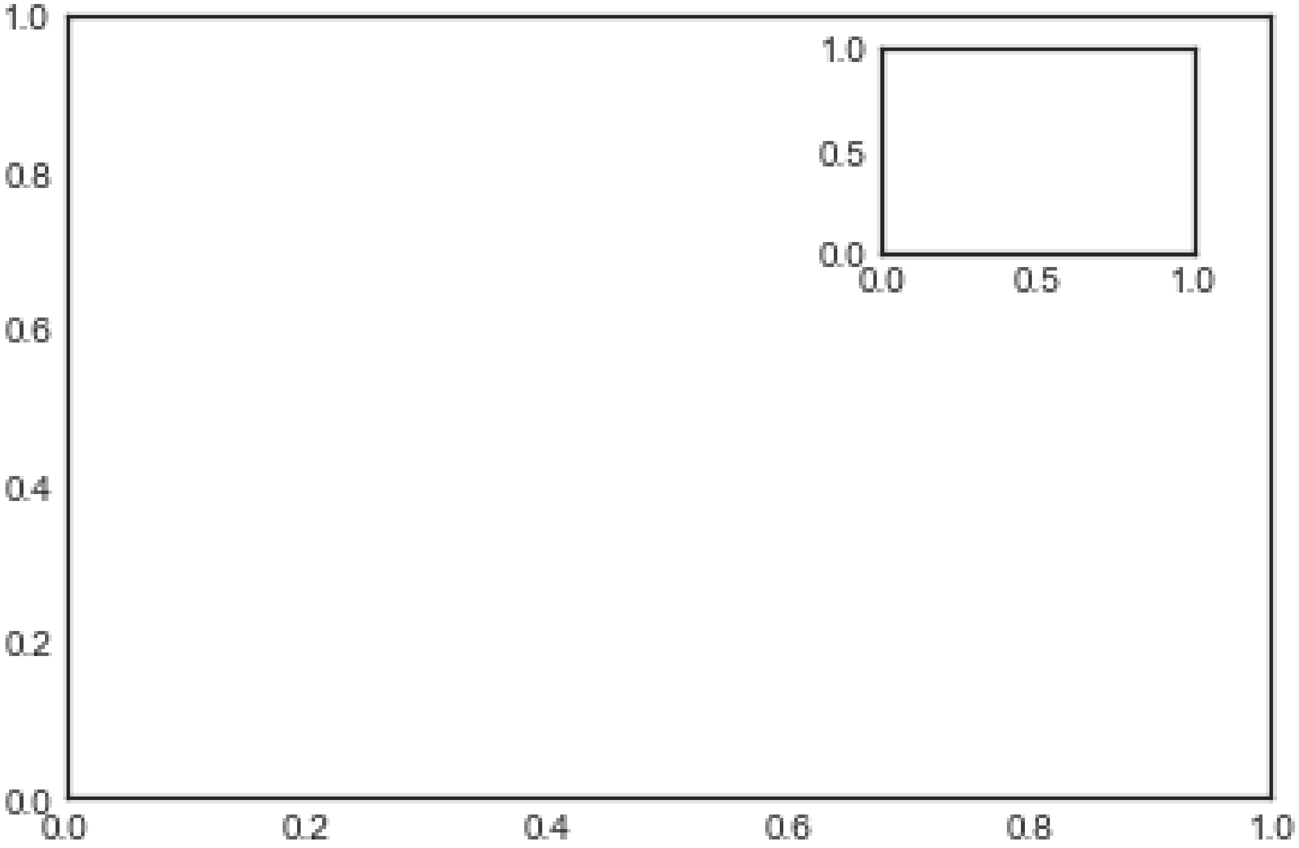
we might create an inset axes at the top-right corner of another axes by setting the *x* and *y* position to 0.65 (that is, starting at 65% of the width and 65% of the height of the figure)

and the *x* and *y* extents to 0.2 (that is, the size of the axes is 20% of the width and 20% of the height of the figure).

The following figure shows the result:

In [ ]:

```
ax1 = plt.axes()  # standard axes
ax2 = plt.axes([0.65, 0.65, 0.2, 0.2])
```



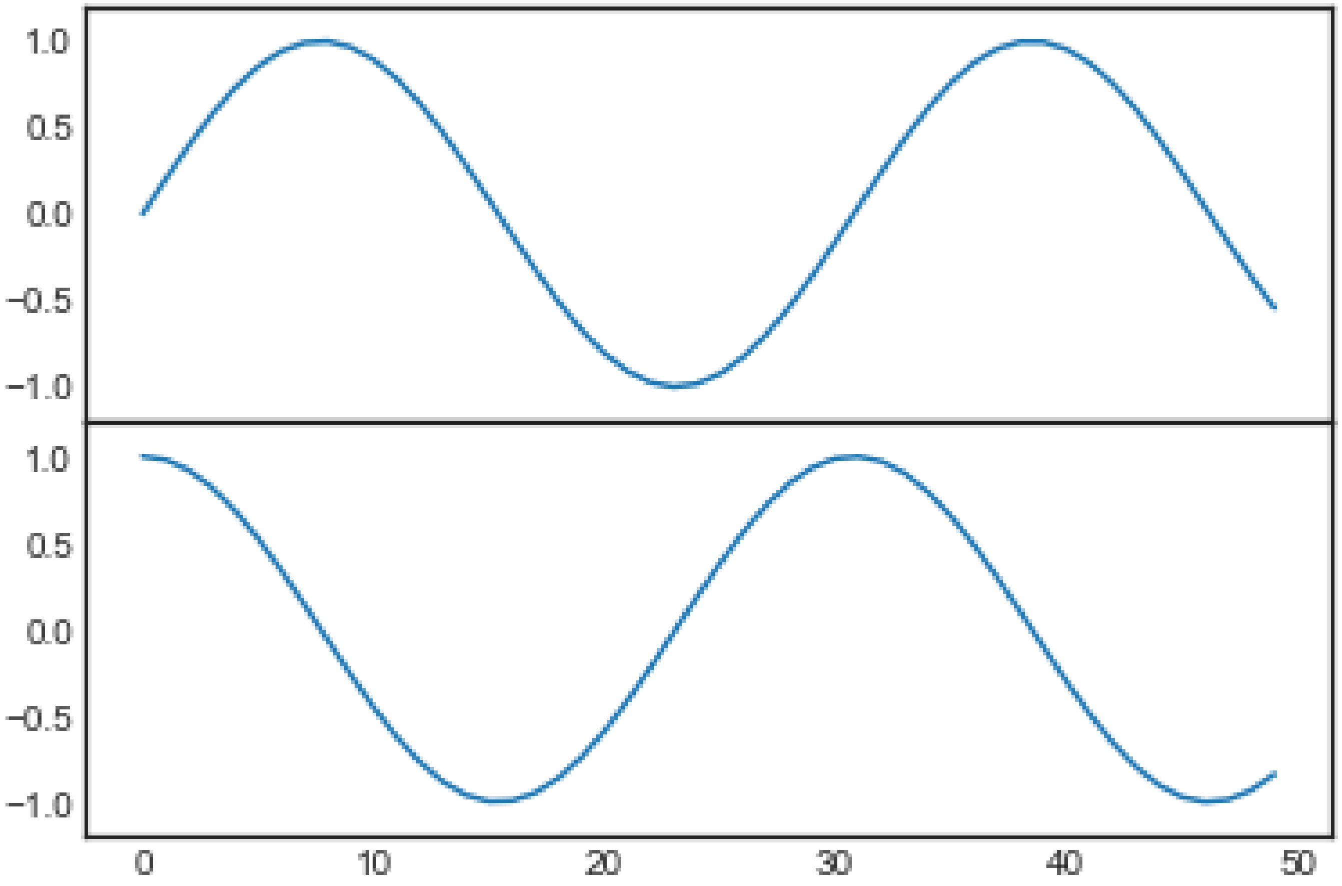
The **equivalent** of this command within the object-oriented interface is `fig.add_axes`.

Let's use this to create two **vertically stacked axes,** as seen in the following figure:

In [ ]:

```
fig = plt.figure()
ax1 = fig.add_axes([0.1, 0.5, 0.8, 0.4],
                   xticklabels=[], ylim=(-1.2, 1.2))
ax2 = fig.add_axes([0.1, 0.1, 0.8, 0.4],
                   ylim=(-1.2, 1.2))

x = np.linspace(0, 10)
ax1.plot(np.sin(x))
ax2.plot(np.cos(x));
```



We now have two axes (the top with no tick labels) that are just touching: the bottom of the upper panel (at position 0.5) matches the top of the lower panel (at position 0.1 + 0.4).

plt.subplot: Simple Grids of Subplots

Aligned columns or rows of subplots are a common enough need that Matplotlib has several **convenience routines** that make them easy to create.

The lowest level of these is `plt.subplot`, which creates a single subplot within a grid.

As you can see, this command takes **three integer arguments**

the number of rows,

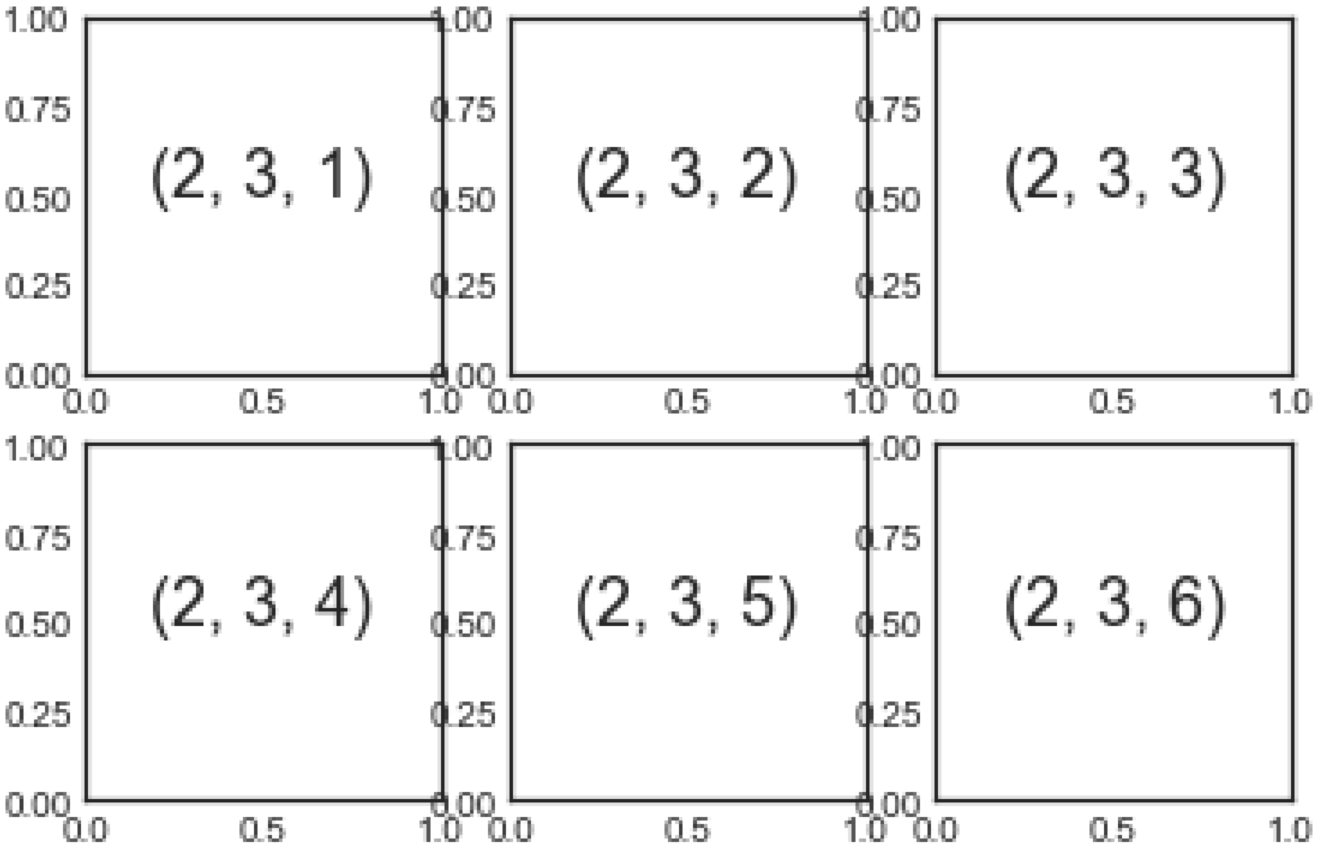
the number of columns,

and the index of the plot to be created in this scheme,

which **runs from the upper left to the bottom right** (see the following figure):

In [ ]:

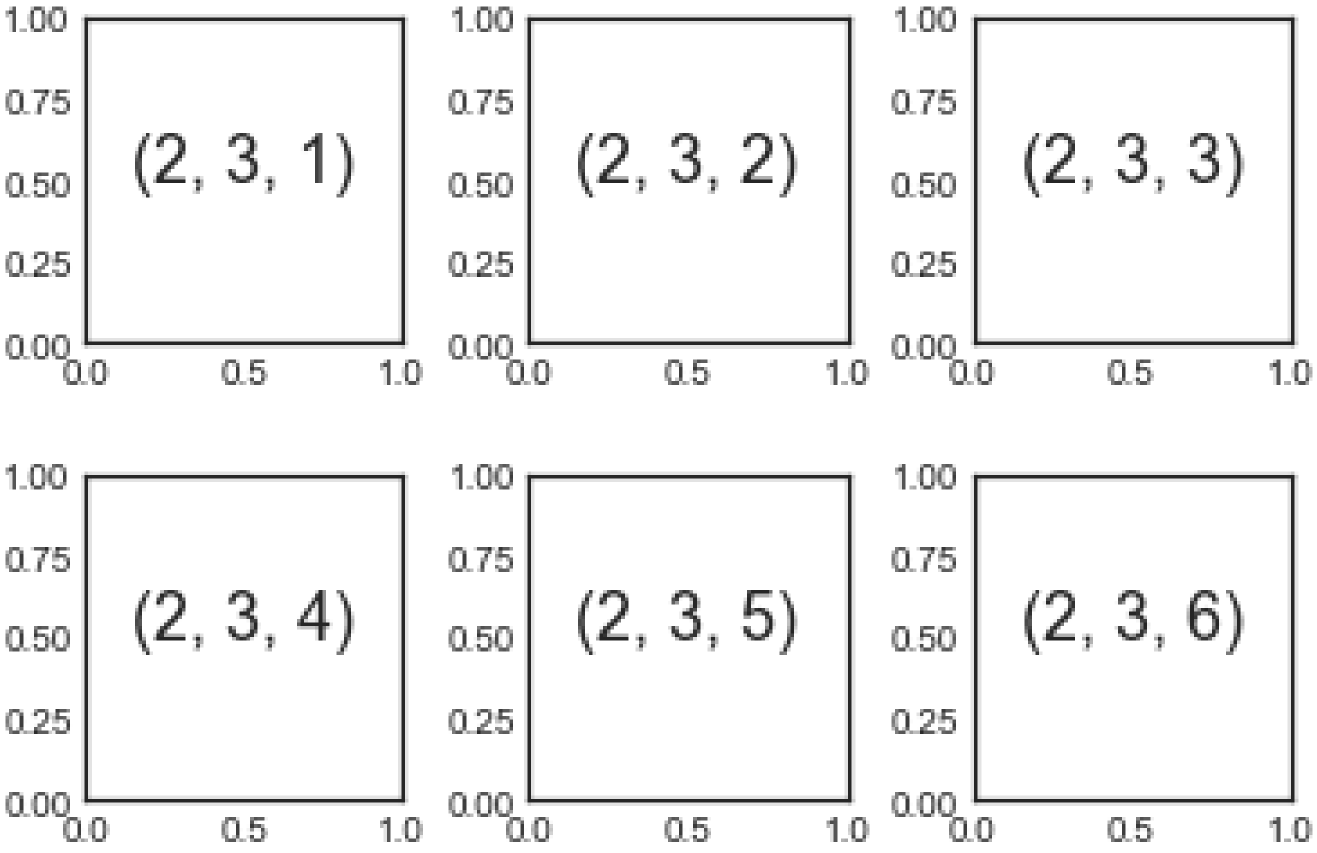
```
for i in range(1, 7):
    plt.subplot(2, 3, i)
    plt.text(0.5, 0.5, str((2, 3, i)),
                fontsize=18, ha='center')
```



The command `plt.subplots_adjust` can be used to adjust the **spacing** between these plots.

The following code uses the **equivalent object-oriented** command, `fig.add_subplot` ;

```
In [ ]: fig = plt.figure()
        fig.subplots_adjust(hspace=0.4, wspace=0.4)
        for i in range(1, 7):
            ax = fig.add_subplot(2, 3, i)
            ax.text(0.5, 0.5, str((2, 3, i)),
                   fontsize=18, ha='center')
```



Here we've used the `hspace` and `wspace` **arguments** of `plt.subplots_adjust`,

which specify the **spacing along the height and width** of the figure, in units of the subplot size (in this case, the space is 40% of the subplot width and height).

plt.subplots: The Whole Grid in One Go

The approach just described quickly becomes **tedious** when creating a large grid of subplots, especially if you'd like to hide the x- and y-axis labels on the inner plots.

For this purpose, `plt.subplots` is the **easier tool** to use (note the `s` at the end of `subplots`).

Rather than creating a single subplot, this function creates **a full grid** of subplots in a single line, returning them in a NumPy array.

The arguments are the **number of rows** and **number of columns,**

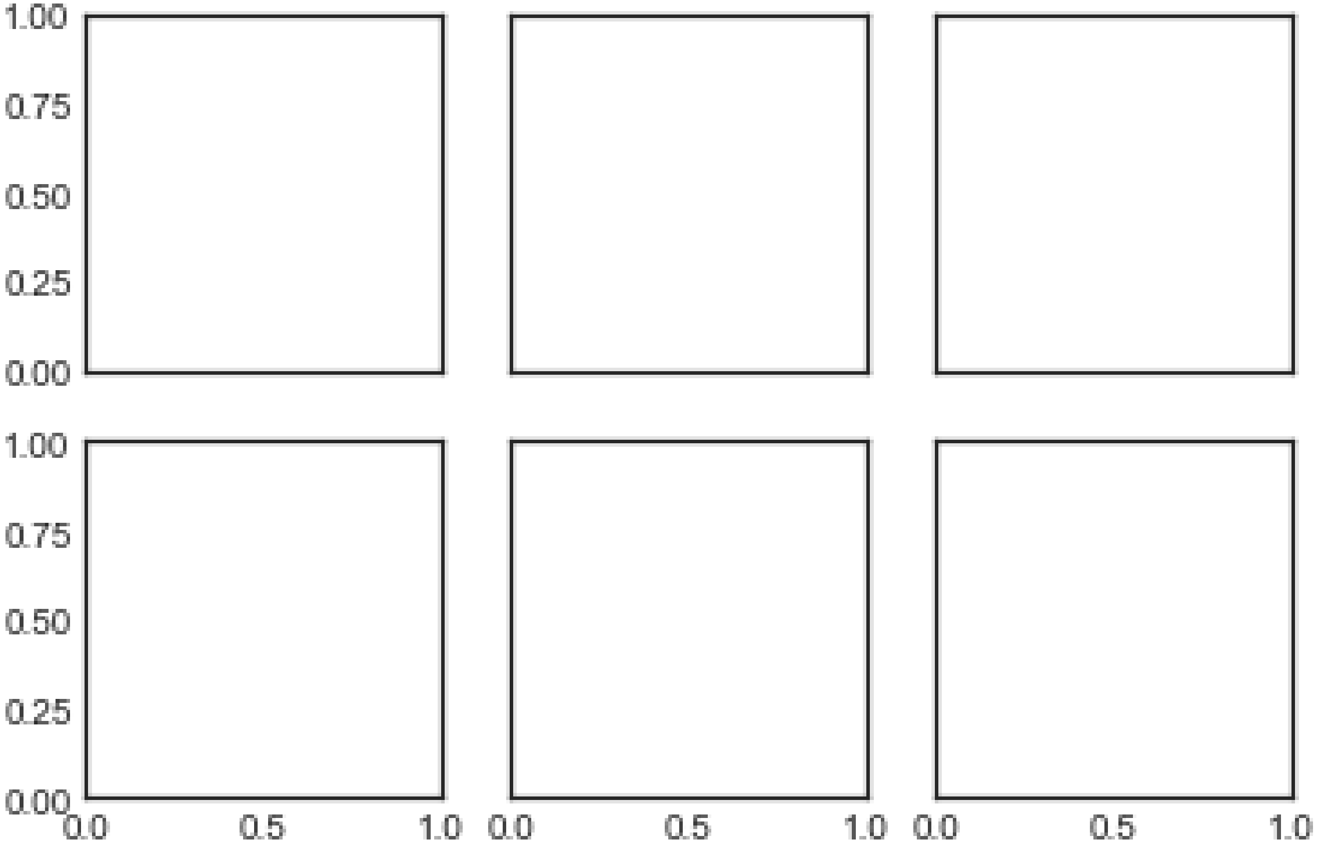
along with **optional keywords** `sharex` and `sharey`, which allow you to specify the relationships between different axes.

Let's create a 2×3 grid of subplots,

where all axes in the same row share their y-axis scale,

and all axes in the same column share their x-axis scale (see the following figure):

```
In [ ]: fig, ax = plt.subplots(2, 3, sharex='col', sharey='row')
```



By specifying `sharex` and `sharey`, we've **automatically removed inner labels** on the grid to make the plot cleaner.

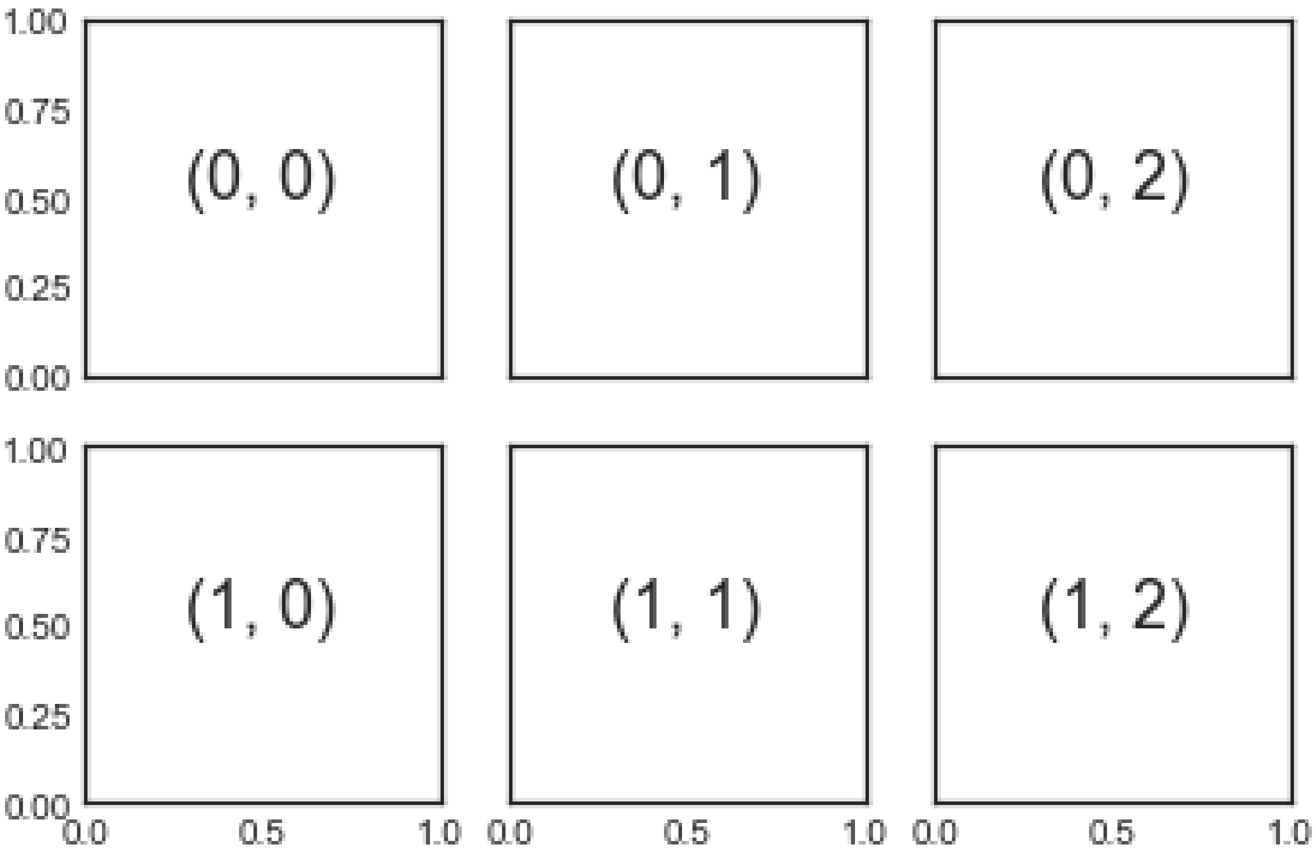
The resulting grid of axes instances is returned within a NumPy array,

allowing for convenient **specification of the desired axes** using standard array indexing notation (see the following figure):

In [ ]:

```
# axes are in a two-dimensional array, indexed by [row, col]
for i in range(2):
    for j in range(3):
        ax[i, j].text(0.5, 0.5, str((i, j)),
                      fontsize=18, ha='center')
fig
```

Out[ ]:



In comparison to `plt.subplot`, `plt.subplots` is more consistent with Python's conventional **zero-based indexing,**

whereas `plt.subplot` uses MATLAB-style **one-based indexing.**

plt.GridSpec: More Complicated Arrangements

To go **beyond a regular grid** to subplots that span multiple rows and columns, `plt.GridSpec` is the best tool.

`plt.GridSpec` does not create a plot by itself;

it is rather a convenient **interface** that is recognized by the `plt.subplot` command.

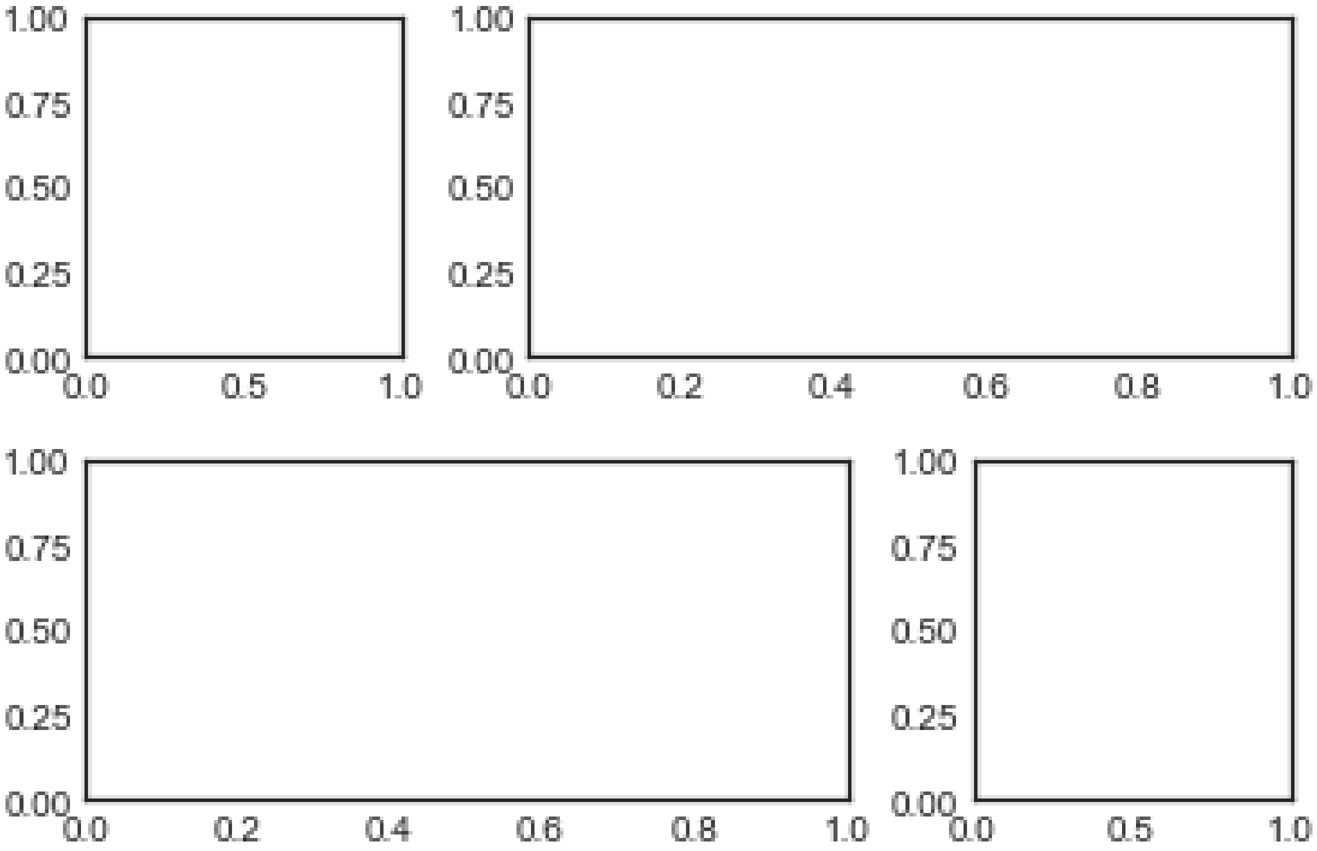
For example, a `GridSpec` for a grid of two rows and three columns with some specified width and height space looks like this:

In [ ]:

```
grid = plt.GridSpec(2, 3, wspace=0.4, hspace=0.3)
```

From this we can specify subplot locations and extents using the familiar Python slicing syntax (see the following figure):

```
In [ ]: plt.subplot(grid[0, 0])
        plt.subplot(grid[0, 1:])
        plt.subplot(grid[1, :2])
        plt.subplot(grid[1, 2]);
```



This type of flexible grid alignment has a **wide range of uses.**

For example: multiaxes histogram plots like the ones shown in the following figure:

In [ ]:

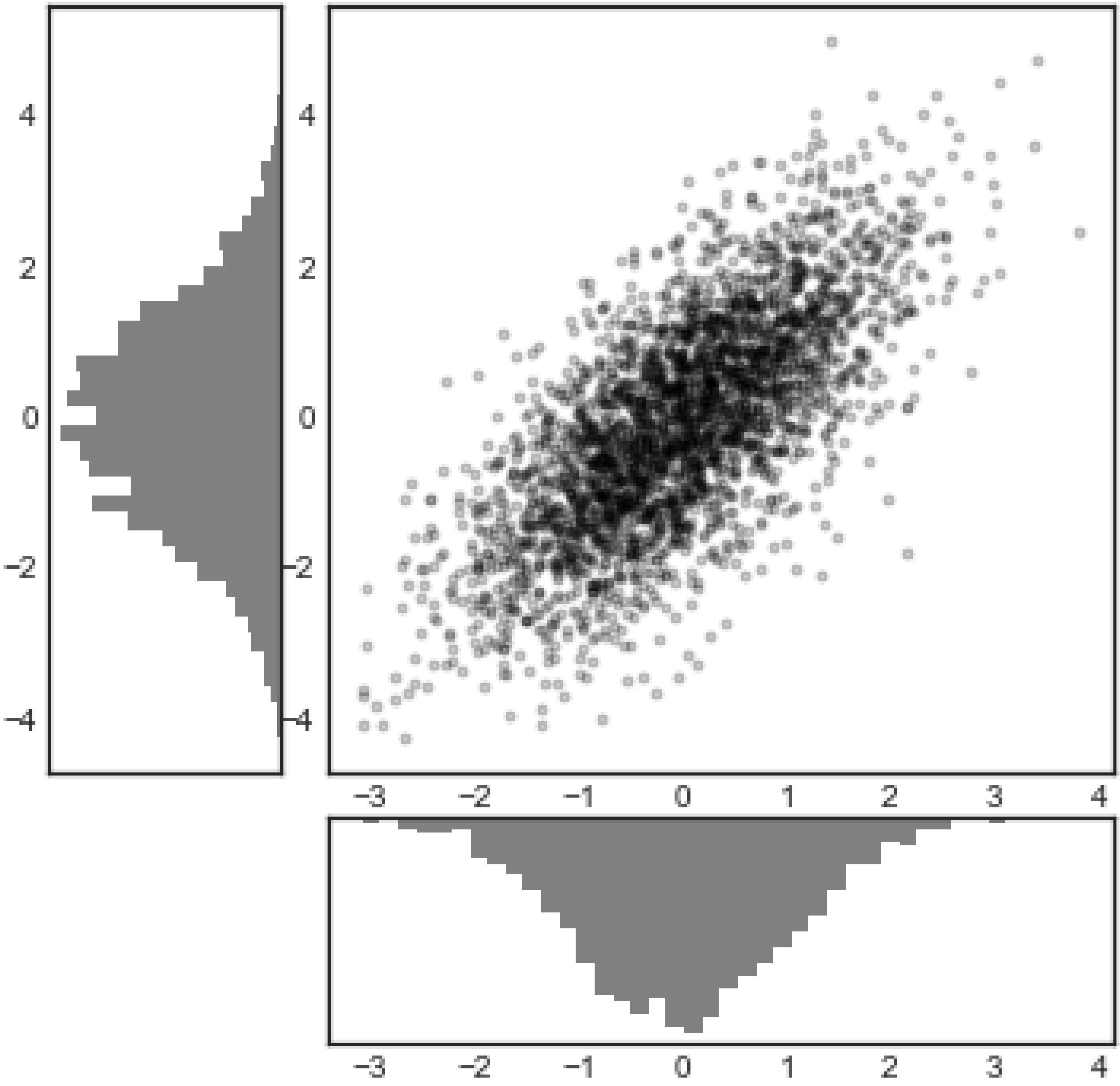
```
# Create some normally distributed data
mean = [0, 0]
cov = [[1, 1], [1, 2]]
rng = np.random.default_rng(1701)
x, y = rng.multivariate_normal(mean, cov, 3000).T

# Set up the axes with GridSpec
fig = plt.figure(figsize=(6, 6))
grid = plt.GridSpec(4, 4, hspace=0.2, wspace=0.2)
main_ax = fig.add_subplot(grid[:-1, 1:])
y_hist = fig.add_subplot(grid[:-1, 0], xticklabels=[], sharey
x_hist = fig.add_subplot(grid[-1, 1:], yticklabels=[], sharex

# Scatter points on the main axes
main_ax.plot(x, y, 'ok', markersize=3, alpha=0.2)

# Histogram on the attached axes
x_hist.hist(x, 40, histtype='stepfilled',
            orientation='vertical', color='gray')
x_hist.invert_yaxis()
```

```
y_hist.hist(y, 40, histtype='stepfilled',
            orientation='horizontal', color='gray')
y_hist.invert_xaxis()
```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