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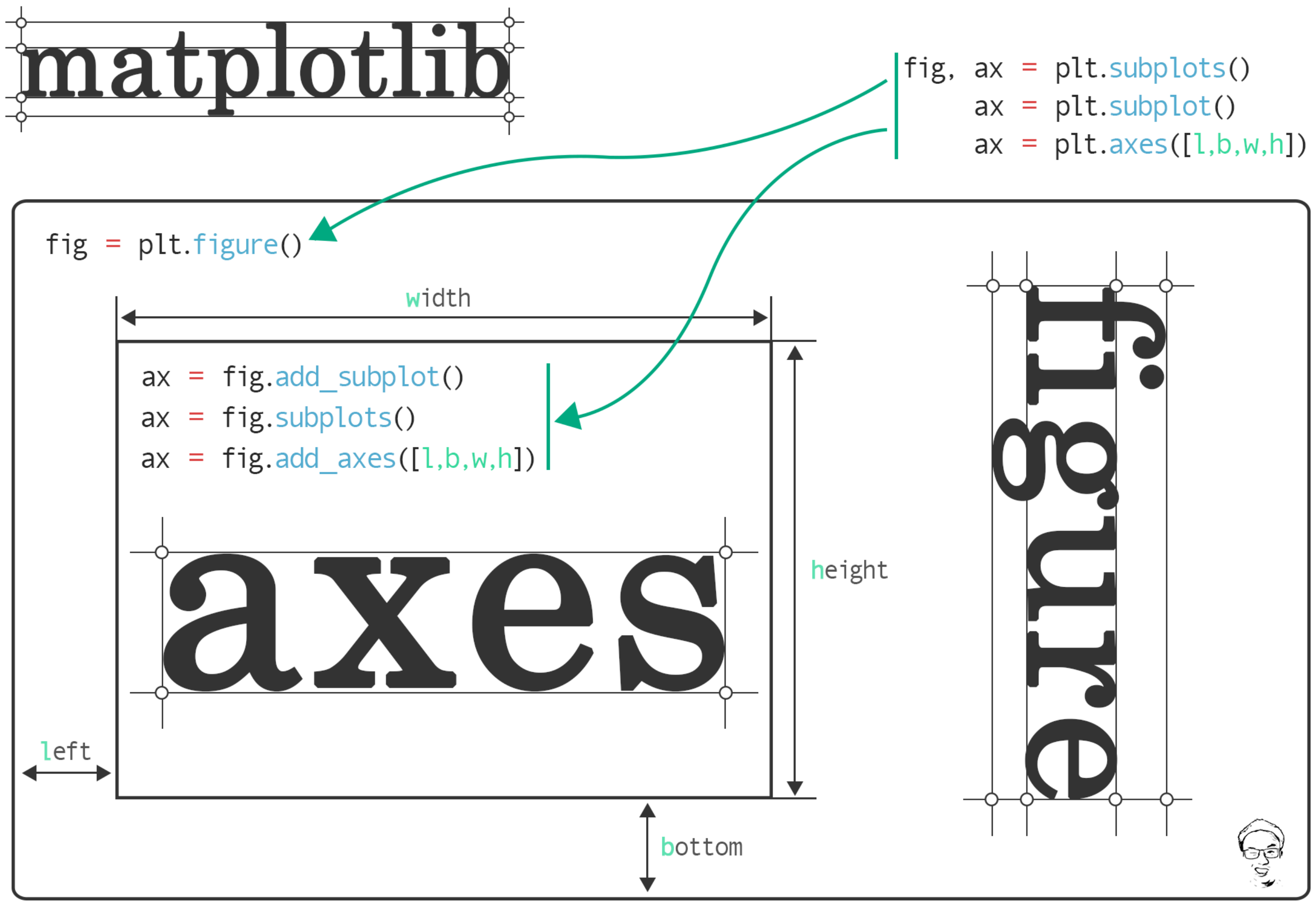

A summary graph by Jun

The Many Ways To Call Axes In Matplotlib

A beginner's notes on learning matplotlib

Jun Jan 17 · 6 min read ★

Although `matplotlib` is extremely powerful and the only limitation might be our imagination, it is a bit challenging for new users to find the right path, as there is always more than one way to achieve the same goal in `matplotlib`. Calling `axes` is one of them.

Let's say you just decide to make plots using **object-oriented interface** (*aka artist layer plotting*) in `matplotlib`. However, I bet you will soon run into problems when trying to instantiate `axes` to start your plotting. You may find that `plt.subplots()` and `plt.subplot()` both can return you `axes`. Yes, they only differ by one letter 's'. Later, you notice that `plt.axes()` can call `axes` as well. It is not over yet, you highly likely will encounter the following functions `fig.add_subplot()`, `fig.add_axes()`, and `fig.subplots()`, which are all able to create `axes` for you. I totally understand how panicked you are or will be, as I have had the same confusion in learning `matplotlib`.

In this post, I will summarise the differences of these functions (*i.e.* *`plt.subplot()`, `plt.subplots()`, `plt.axes()`, `fig.add_subplot()`, `fig.subplots()`, and `fig.add_axes()`*) and demonstrate how to use them accordingly.

In `matplotlib` terminology, a basic plot starts from one `figure` and at least one `axes` (*if you are confused about these terms, you may find this post is useful*). A close analogy with painting, `figure` is the canvas and `axes` is the artistic composition. A canvas (*`figure`*) can have only one type or many different types of artistic composition (*`axes`*) on it. In light of this, let's first start from a simple case for `figure` with only one `axes`, then dive into `figure` with multiple `axes`.

`Figure` with only one `axes`

In most circumstances, we instantiate a `fig` object by calling `fig = plt.figure(…)` and then add an `axes` object to the `fig` by calling `ax = fig.add_subplot()`. By default, if leave the parentheses empty, this function is passed with `fig.add_subplot(1, 1, 1)`, which means add # 1 `axes` in a 1 row by 1 column `axes` grid. We can also use an alternative format with 3-digit integer without comma (*i.e.* `fig.add_subplot(111)`). However, with the 3-digit integer format, each integer cannot be greater than 9. Using this function, we add only one `axes` at a time.

```
# Create a figure
fig = plt.figure()

# Add a subplot
ax = fig.add_subplot()

# Equivalent method
ax = fig.add_subplot(111)

# Another equivalent but more general method
ax = fig.add_subplot(1, 1, 1)
```

Sometimes, we are able to add an `axes` object using `ax = fig.subplots()`. This function is originally devised to make it convenient to create a set of subplots in **common layouts** by a single call. It takes `nrows` and `ncols` as positional arguments (*i.e. this function is supposed to add multiple* `axes` *at a time*). However, if we leave the parentheses empty, this function is passed with `fig.subplots(1, 1)` by default, which means create an `axes` grid with 1 row by 1 column (*i.e. one* `axes` *on* `fig`). Hence the `axes` only contain one item in it (*i.e.* `len(ax)` *is 1*).

```
# Create a figure
fig = plt.figure()

# Create a subplot
ax = fig.subplots()

# Equivalent method
ax = fig.subplots(1, 1)
```

Rarely, as for `figure` with one plot, we may also use `ax = fig.add_axes([left, bottom, width, height])` to add an `axes` onto a `fig`. This function enables **arbitrary layouts** of `axes` on `fig` by taking the dimensions (*`[left, bottom, width, height]`*) of the new `axes` (*you can find an example here*). All four numbers should be in fractions of `figure` width and height. In other words, we control the position and size of the `axes` . `fig.add_axes([0, 0, 0.78, 0.78])` creates the same size plot as by `fig.add_subplot(111)` and `fig.subplots(1, 1)` . As you can see here, `axes` is not in the same size as `figure` . There is white space between `axes` and `figure` by default.

```
# Create a figure
fig = plt.figure()

# Add a subplot
ax = fig.add_axes([0, 0, 0.78, 0.78])
```

After demonstrating the differences of the above three functions, it is fairly easy to understand `plt.subplot()` , `plt.subplots()` , and `plt.axes()` . They are from **state-based interface** (*aka scripting layer plotting*) of `matplotlib` , which just wrapped `fig = plt.figure()` with `fig.add_subplot()` , `fig.subplots()` , and `fig.add_axes()` , correspondingly.

`plt.subplot()` returns only one `axes` and create a `figure` object automatically. You can change `figure` -level attributes or save the `figure` by calling `ax.figure.xxx()` instead. For example, `ax.figure.savefig('example.png')` will save the `figure` as `example.png` .

```
# Creates just a figure and only one subplot
ax = plt.subplot()

# Equivalent method
fig = plt.figure()
ax = fig.add_subplot(1, 1, 1)
```

`plt.subplots()` returns a tuple containing a figure and axes object(s). We need to unpack this tuple and assign its items to variables `fig` and `ax` , respectively.

```
# Creates just a figure and only one subplot
fig, ax = plt.subplots()

# Equivalent method
fig = plt.figure()
ax = fig.subplots(1, 1)
```

`plt.axes()` returns one `axes` using `fig.add_subplot(1, 1, 1)` when no argument is provided and, just like `plt.subplot()`, it creates a `figure` object automatically. `plt.axes()` also accept dimensions (*`[left, bottom, width, height]`*) using `fig.add_axes([left, bottom, width, height])` in its backend. The following two sets of code create the same plots.

```
# Set one
# Creates just a figure and only one subplot
ax = plt.axes()

# Equivalent method
fig = plt.figure()
ax = fig.add_subplot(1, 1, 1)

-------------------------------------------

# Set two
# Creates just a figure and only one subplot
ax = plt.axes([0, 0, 0.78, 0.78])

# Equivalent method
fig = plt.figure()
ax = fig.add_axes([0, 0, 0.78, 0.78])
```

`Figure` with multiple `axes`

When it comes to plotting multiple `axes` on `figure`, the differences among these functions (*i.e. `plt.subplot()`, `plt.subplots()`, `plt.axes()`, `fig.add_subplot()`, `fig.subplots()`, and `fig.add_axes()`*) become manifest. Again, let’s demonstrate this using examples. Since `plt.subplot()`, `plt.subplots()`, and `plt.axes()` are essentially the same as `fig.add_subplot()`, `fig.subplots()`, and `fig.add_axes()`, I will only show examples for the latter three functions.

As stated above, we add one `axes` at a time when using `fig.add_subplot()`. The build-in order of `axes` is started from left to right and from top to bottom within the `axes` grid (Figure 1).

```python
fig = plt.figure()
ax1 = fig.add_subplot(221)
ax2 = fig.add_subplot(222)
ax3 = fig.add_subplot(223)
ax4 = fig.add_subplot(224)

ax1.annotate('I am ax1', (0.5, 0.5),
             xycoords='axes fraction', va='center', ha='center')
ax2.annotate('I am ax2', (0.5, 0.5),
             xycoords='axes fraction', va='center', ha='center')
ax3.annotate('I am ax3', (0.5, 0.5),
             xycoords='axes fraction', va='center', ha='center')
ax4.annotate('I am ax4', (0.5, 0.5),
             xycoords='axes fraction', va='center', ha='center')
plt.tight_layout()
```

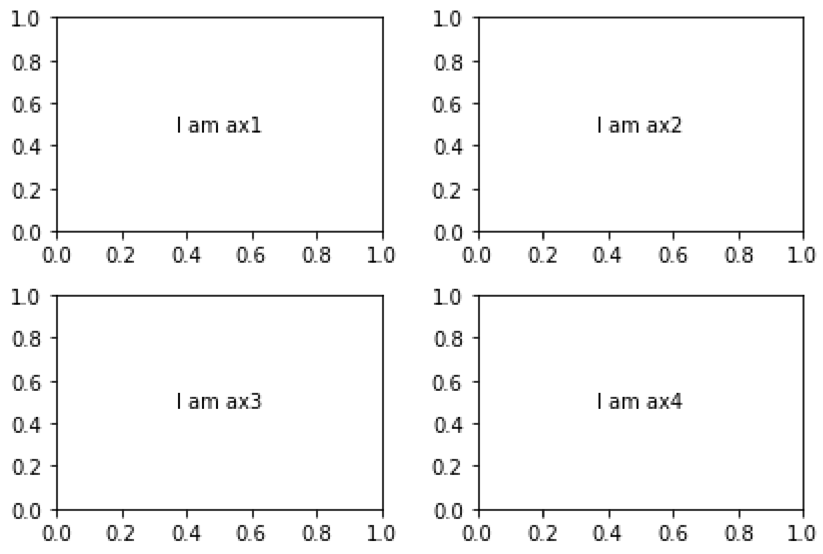

Fig 1. fig.add_subplot() create a 2 by 2 axes grid

The same layout could be obtained using `fig.subplots()` with one line of code (Figure 2). It returns a `ndarray` object `axs` (*I add a 's' after* `ax` *to show that it contains multiple objects*). Just like an 2D array object, each `ax` within `axs` can be accessed using `axs[x, y]` as well (*i.e. ax1 can be accessed using axs[0, 0]*). Moreover, if you like to assign names to each `ax` within `axs`, you can use tuple unpacking like this, `((ax1, ax2), (ax3, ax4)) = fig.subplots(nrows=2, ncols=2)`. Flattening of 2D array is another method to access `ax` from `axs` as shown in Figure 2.

```
fig = plt.figure()
axs = fig.subplots(nrows=2, ncols=2)

axs.flat[0].annotate('I am ax1', (0.5, 0.5),
                     xycoords='axes fraction', va='center', ha='center')
axs.flat[1].annotate('I am ax2', (0.5, 0.5),
                     xycoords='axes fraction', va='center', ha='center')
axs.flat[2].annotate('I am ax3', (0.5, 0.5),
                     xycoords='axes fraction', va='center', ha='center')
axs.flat[3].annotate('I am ax4', (0.5, 0.5),
                     xycoords='axes fraction', va='center', ha='center')

plt.tight_layout()
```

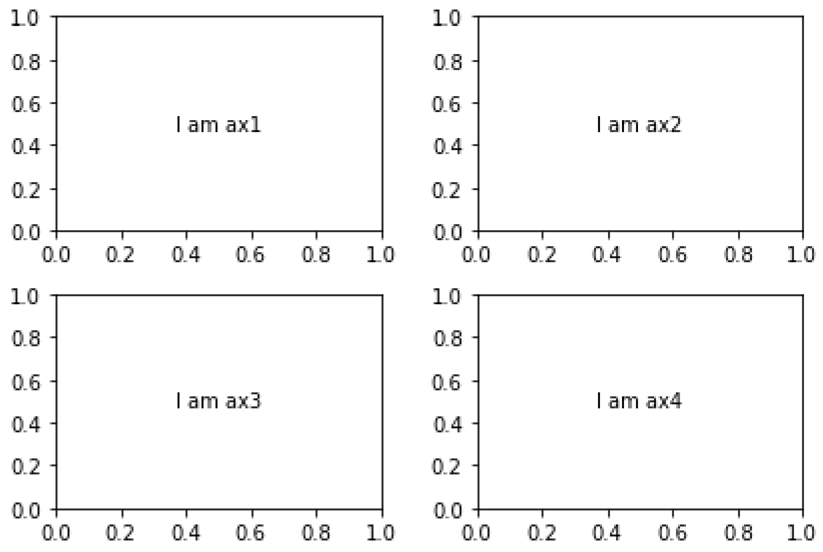

Fig 2. fig.subplots() create a 2 by 2 axes grid

Normally, `fig.add_axes()` is used for arbitrary layouts, such as a plot with inlet subplots or subplots overlap with each other. This is because we can fine-tune the position and size of each subplot by its dimensions (*`[left, bottom, width, height]`*). Having said that, we still can make a common layout as shown in Figure 1 and 2 using `fig.add_axes()` (Figure 3).

```
fig = plt.figure()
ax1 = fig.add_axes([0, 0.6, 0.5, 0.5])
ax2 = fig.add_axes([0.6, 0.6, 0.5, 0.5])
ax3 = fig.add_axes([0, 0, 0.5, 0.5])
ax4 = fig.add_axes([0.6, 0, 0.5, 0.5])

ax1.annotate('I am ax1', (0.5, 0.5),
                     xycoords='axes fraction', va='center', ha='center')
ax2.annotate('I am ax2', (0.5, 0.5),
                     xycoords='axes fraction', va='center', ha='center')
ax3.annotate('I am ax3', (0.5, 0.5),
                    xycoords='axes fraction', va='center', ha='center')
ax4.annotate('I am ax4', (0.5, 0.5),
                    xycoords='axes fraction', va='center', ha='center')

plt.show()
```

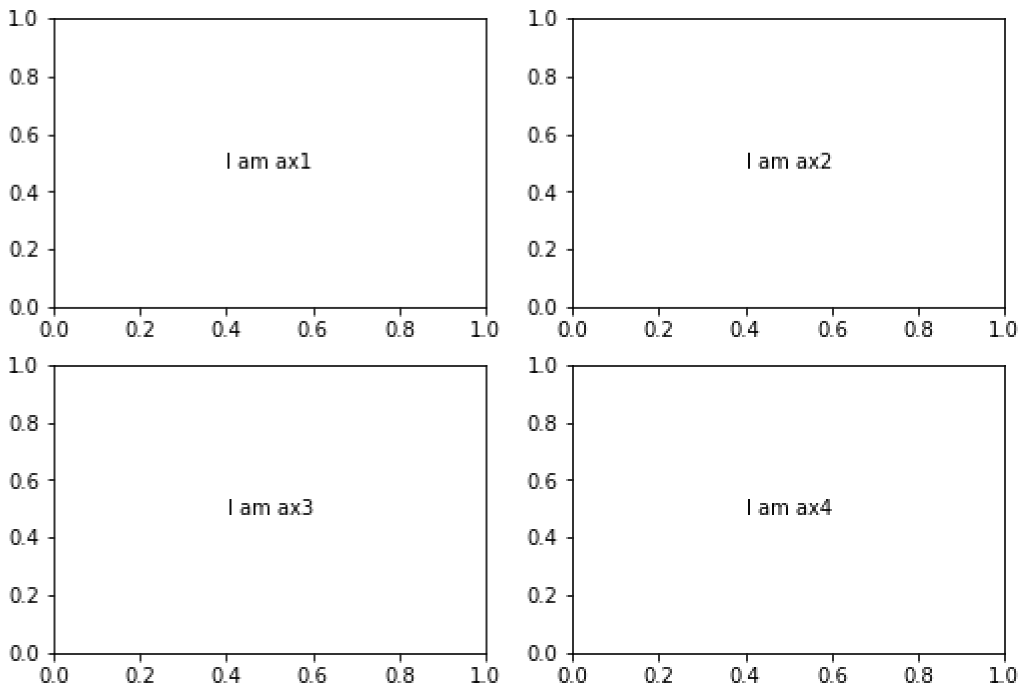

Fig 3. fig.add_axes() create a 2 by 2 axes grid

In summary, these six functions (*concisely should be three functions, i.e.* *`fig.add_subplot()`, `fig.subplots()`, and `fig.add_axes()`*) can be used interchangeably when you are making a `figure` with only one `axes`. However, they have respective strengths and can be used individually or in combination when it comes to making `figure` with multiple `axes` in different layouts.

After reading this post, I hope you have a clearer understanding of how to call `axes` in `matplotlib`. All the codes in this post can be accessed from this jupyter notebook. If you know other functions/cases to call `axes` which are not listed here, please feel free to leave your comment. Let's learn `matplotlib` together.

As always, I welcome feedback, constructive criticism, and hearing about your data science projects. I can be reached on Linkedin and on my website as well.

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