09 - Data analysis and drawing

Now let's bite into the bigger bite: weather data.

We'll use a data file in this format:

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Automatisch generierte Beschreibung

Read with np.genfromtxt; tell it to delimit the data with commas (delimited=",") and to read it as strings of up to 20 characters (dtype="U20").

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Automatisch generierte Beschreibung

As in the stock exchange minutes, we turn the columns into rows and store them in separate variables.

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Automatisch generierte Beschreibung

If we are only interested in data for Ljubljana, let's build a mask.

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Automatisch generierte Beschreibung

For simplicity, let's now just throw out the data for the other places.

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Automatisch generierte Beschreibung

Ah, that's so annoying. It would be simpler to apply a mask to the whole table and then unpack. Repeat the exercise.

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Automatisch generierte Beschreibung

We don't care about the location (it's always Ljubljana anyway), so we just saved it in \_.

Now comes the fun part: we'd like a table with the (maximum) temperatures for each day. The table would have three indices: year, month and day. So temp[71, 0, 25] would be the temperature on 26 January 71. Obviously, this will be a three-dimensional table. Let's prepare it: at the beginning it should contain only np.nan, not a number.

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Automatisch generierte Beschreibung

Now it needs to be filled with data. The date column will need to be unpacked.

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Automatisch generierte Beschreibung

At first glance: you want the whole table (all strings), but only the first four characters for each.

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Automatisch generierte Beschreibung

No, this table is one-dimensional and does not allow a second index. Numpy functions for working with array tables are in np.char. The view stops at np.char.split, but this doesn't make us happy, because it returns a table of lists, and we can't help ourselves with them.

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Automatisch generierte Beschreibung

Partition saves us. (There may be something else, simpler. This part of numpy is not my strong area.)

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Automatisch generierte Beschreibung

Python arrays also have a partition method, and the result is the same: three arrays - everything before the character you're partitioning by, then that character, and then everything after it. Here, in numpy, instead of three strings, we get three columns of strings. We invert, we break into rows. We divide the last one again.

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Automatisch generierte Beschreibung

This gives us three lists containing all the years, months and dates from all the lines in the file. The corresponding temperatures are in tmax, also by line. And now we can overwrite them in the temp table.

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Automatisch generierte Beschreibung

We subtract 1900 from the year, and 1 from each month and day, because for some reason people don't count years from 1900 onwards, and months and days from 0.

Here we have it: the maximum daily temperature on 26 January 1971 was

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Automatisch generierte Beschreibung

What have been the average monthly temperatures since 2019?

We take the temp[119:] (because we subtracted 1900 years) and calculate the nanmean on axis 2. Axis 2 is the days of the month - we want to calculate the average over them.

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Automatisch generierte Beschreibung

The above warning refers to the last two items: we don't have data for November and December 2023 (I picked up a 7 GB file with data for the whole world in October 2023), so nanmean has returned nan there.

What about average monthly temperatures in general?

In this case we average over years and days, only the months need to remain. So the axes will be 0 and 2.

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Automatisch generierte Beschreibung

We know better.

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Automatisch generierte Beschreibung

OK, enough fiddling: isn't it time we drew a real graph of temperatures?

**Drawing graphs**

There are, of course, several libraries for drawing graphs, which work in different environments. For our purposes, the simplest one is the one that gets along well with Jupyter Notebook. (Incidentally, I must admit that I don't draw in Notebook myself, but elsewhere with other libraries, so I'm not a particular expert on `matplotlib'.)

Install it with `pip install matplotlib`. If we have several Pythons and we're not good at this, and we don't know where we have `pip` and so on, it's easiest to just install it in Jupiter. We're going to use it inside Jupyter anyway, so there's nothing wrong if it might only be installed in the environment we're using for Jupyter.

In the cell you write

```

%pip install matplotlib

```

and execute it, and it will. If you don't have matplot yet, you will then need to restart Python using Kernel/Restart.

Now import `pyplot` from the `matplotlib` module under the name `plt` (to reduce typing).

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Automatisch generierte Beschreibung

One last thing:

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Automatisch generierte Beschreibung

These are the magic words that tell matplotlib to display the images in the notebook. At least one alternative that should probably work is %matplotlib qt: the graphs will be in a separate window. inline is more practical and, at least for me, seems to be the default.

Then open the matplotlib web page and choose a graph type. For temperatures, probably the most suitable will be bars, [https://matplotlib.org/stable/plot\_types/basic/bar.html#sphx-glr-plot-types-basic-bar-py].

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Automatisch generierte Beschreibung

Since I know that nobody will ask whether this graph can also be drawn horizontally, because that is stupid, I will do it on my own initiative.

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Automatisch generierte Beschreibung

To make it look a little less awkward, let's reverse the `y` axis.

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Automatisch generierte Beschreibung

plt.axes()?! A person who is not familiar with matplotlib would naturally think that these are the axes of a graph. In fact, the axes are what "draw" the graph. The very first thing we did is actually just a shorthand for

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Automatisch generierte Beschreibung

Let's not go further in that direction - at least not until we have to. Let's look at this instead: if we want to draw a curve instead of columns, we call

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Automatisch generierte Beschreibung

But no one is stopping us from drawing both.

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Automatisch generierte Beschreibung

Oh, um, no, I didn't mean that ... I meant the same picture. But, anyway, while we're here - what is it?!

I used plt.figure(figsize=(13, 4), dpi=96) to say that I wanted a 13x4 inch figure (because inches, i.e. 2.54 centimetres, is the most standard unit of length, ever since all units switched to the decimal system, in Europe, say, sometime around the time of the French Revolution), and that I wanted a resolution of 96 pixels per inch. In short, an image of

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Automatisch generierte Beschreibung

pixels (pixels, in local terms). Why not give the resolution in pixels? Why in inches? If not centimetres? It is one thing what happens when we save the image. If the program we load it into is anything clever, it will keep those dimensions. The image will be large



centimetres. Second, the font size is given in the units we know from office software, points. As you may or may not know, 1 pt equals 1/72 of an inch; 12 pt is therefore 12/72 of an inch, so 12/72 \* 2.45 cm, that is, just under half an inch.



Since the font is given in inches, we need to give the resolution of the image in dots per inch to determine how many dots (say on the screen) high the letter is.

We continued with

ax = plt.subplot(1, 2, 1)

ax.bar(calendar.month\_abbr[1:], monthly, alpha=0.2)

ax = plt.subplot(122)

ax.plot(calendar.month\_abbr[1:], monthly)

axes will be the "axes" that draw the graphs. With plt.subplot(1, 2, 1) we say that we would like to place the images in a grid with 1 row and 2 columns, and that we would now like to talk about the first of the images in this grid. Therefore 1, 2, 1. Then we draw the columns in this image. alpha=0.2 makes the columns a bit more transparent, brighter.

Then we say that we would draw the second image in this grid with 1 row 2 columns. Because we are lazy, we write 122 without commas. And then we draw the second picture.

But, as I said, I would like both in the same picture. This is simpler, of course. :)

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Automatisch generierte Beschreibung

Why would anyone want that? I don't know. This picture shows the same thing twice. Edward Tufte would be turning in his grave if (a) he saw it and (b) he were no longer alive, but fortunately he is. (And if you ever get your hands on one of his books, just flick through it!)

It would be more appropriate to plot the maximum and minimum monthly temperature and the average. The graph we need is called fill\_between and in addition to the x-axis data, we give two y-axis data - the upper and lower bounds. Over this, of course, we plot the average.

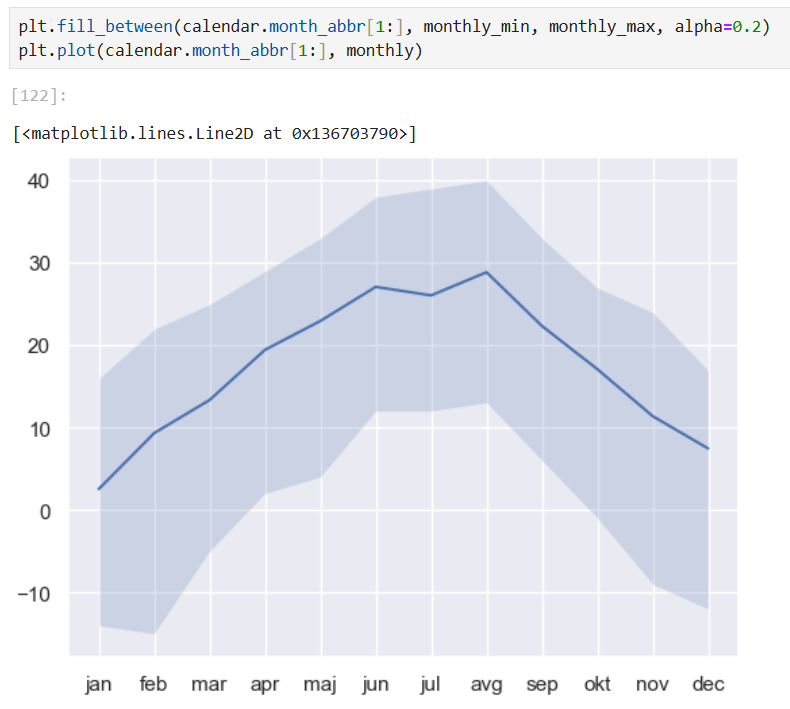
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Automatisch generierte Beschreibung

If you want nicer pictures, install `seaborn`: do `%pip install seaborn`, restart Python (Kernel / Restart), import it and set its theme.

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Automatisch generierte Beschreibung

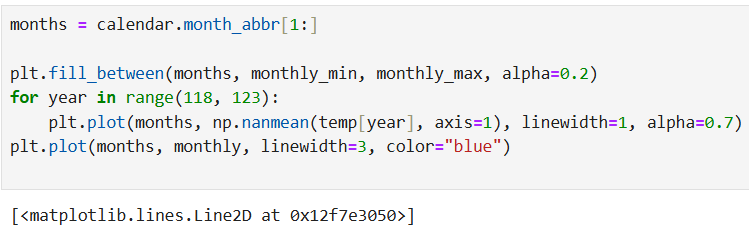
  
Save? Let's go! In png? Or svg? Maybe pfd? Right, pdf.

Ein Bild, das Text, Screenshot, Diagramm enthält.

Automatisch generierte Beschreibung

Different formats will work; at least .png will work everywhere, but the others depend on how your Jupyter is put together.

Would you add the average monthly temperatures for the last ten years to this graph?



Ein Bild, das Diagramm, Screenshot, Reihe, Steigung enthält.

Automatisch generierte Beschreibung

We are playing a little game: we have narrowed and lightened the lines for individual years, thickened the average and explicitly asked for it to be blue.

Not very convincing. Perhaps we would have preferred to replace the lines with circles?

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Automatisch generierte Beschreibung

Ein Bild, das Diagramm, Screenshot, Reihe, Steigung enthält.

Automatisch generierte Beschreibung

If we are interested in looking at something by month - maybe a moustache?

Let's make a list of tables: each element will contain all the temperatures measured in that month, in any year.

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Automatisch generierte Beschreibung

With temp[:, month, :] we say that for the given month we would like all "rows" and "columns" - all years and days. The table will be two-dimensional - the first index will be the year, the second the day. With flatten, we push it into a single dimension. With x[~np.isnan(x)], we fix only those elements that are not nan - that is, only known measurements.



since the function returns a bunch of things, we store them in `fig` so they don't get printed out

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Automatisch generierte Beschreibung

A similar thing, violins, show distributions.



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Automatisch generierte Beschreibung

How about this? Let's plot average monthly temperatures by decade.

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Automatisch generierte Beschreibung

Ein Bild, das Diagramm, Reihe, Screenshot enthält.

Automatisch generierte Beschreibung

But this is quite interesting: it shows that the temperature is rising over the years. Who would have thought?

But here's how the average monthly temperature varies by year.

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Automatisch generierte Beschreibung

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Automatisch generierte Beschreibung

We will stop here. I hope that's enough for you to see that serious graphs are not drawn with Excel. Matplotlib is probably the most serious graphing tool in science, next to R.

What we have seen here is nothing of the sort. We haven't scratched the surface yet. Take a walk through the gallery and you will see that there is probably everything you will ever need. And next to each image, there is a code that prints it out - a code that you can copy and adapt to your needs.