Visualization in Python with matplotlib

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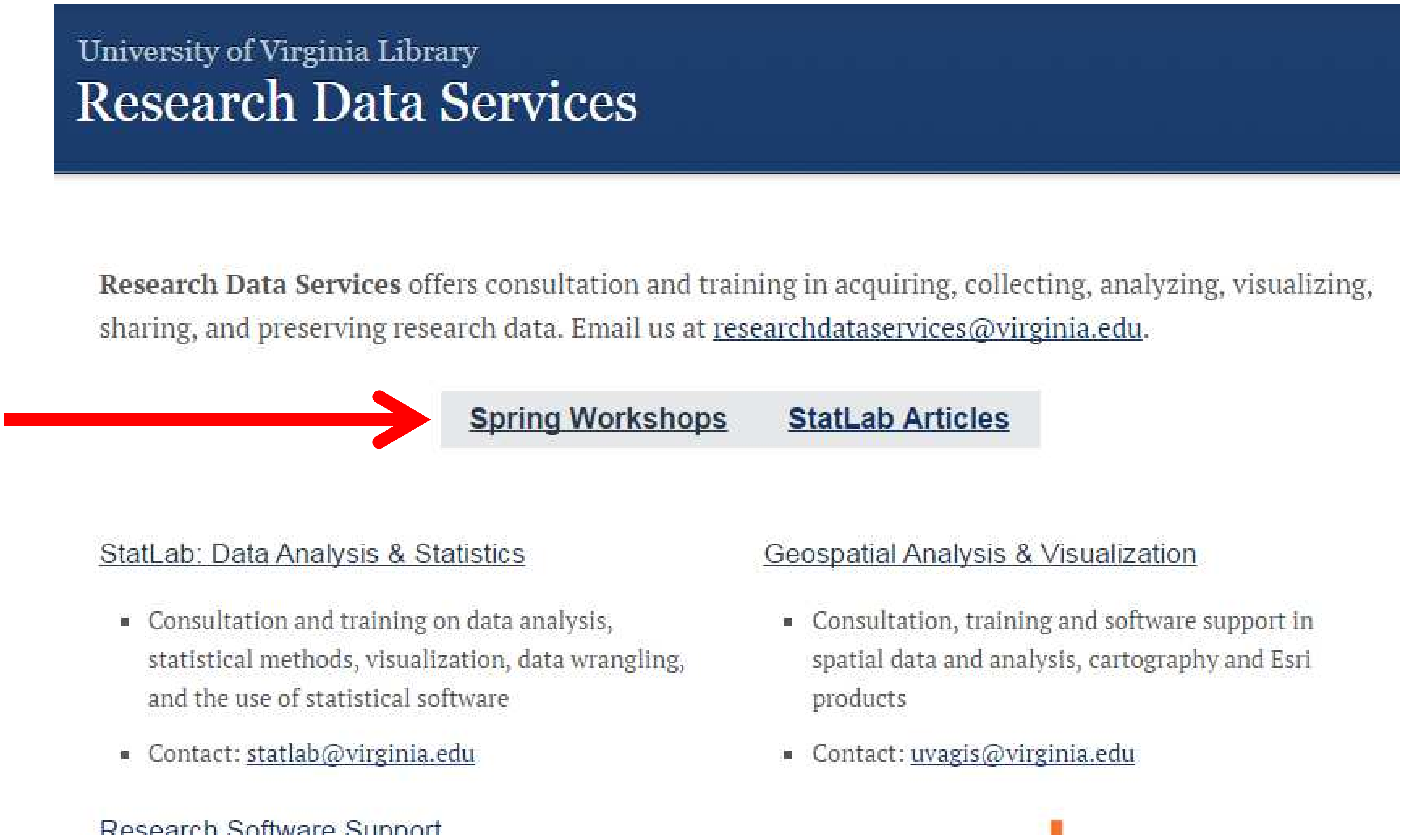

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Research Software Support

What we’re gonna do today

- 2-3:30
- Get everyone up and running with python
- python interfaces
- Loading matplotlib
- Plotting 101 (create and save)
- Histograms, scatter plots
- Cosmetics
- multiplots

Installation of Python

- Two Notes
  - Language (python) vs language distribution (anaconda)
  - Python 2 vs Python 3
- https://www.continuum.io/downloads
  1. Scroll to your operating system
  2. Click on the blue box under Python 2.7
  3. Follow the instructions

Interfaces

- Command line interpreter (and ipython)
- Commandline script execution
- Ipython notebook / jupyter
- Spyder (generalize to ide)

Loading matplotlib

- It depends on your interface

A basic plot

- `C:\Users\lpa2a>python`
- `>>> import matplotlib.pyplot as plt`
- `>>> x=range(10)`
- `>>> plt.plot(x)`
- `>>> plt.show()`

Why blue?
Why a line?
Why a line with slope of 1?
Why does it hang after show?

Saving a plot

- There are two ways to save the plot:
  - Use the command line:
    - `>>> plt.savefig('test.pdf')`
    - Must be done before the show command
  - Use the gui:
    - Click the save icon
    - Type in the file name
    - select the file type

Window control

- Notice when we use `plt.show()` we lose control.
- To regain control we must close the plot window.
- Now we'll go through other ways of interacting with matplotlib to avoid this problem.

IPython + %pylab

- Instead of loading up python at the command line with `python` use `ipython` instead.
- Ipython has a special plotting mode which you load by issuing the command %pylab
- `C:\Users\lpa2a>ipython`
- `In [1]: %pylab`
- Now we can try our basic plot again.
  - Don't need to load matplotliab
  - We don't need to use the "`plt.`"
  - We don't loose control when we plot
  - Plot appears on plot command, no more `show()`

Command line scrip execution

- Let’s take a look at C:\Users\lpa2a\plot.py

Ipython Notebook

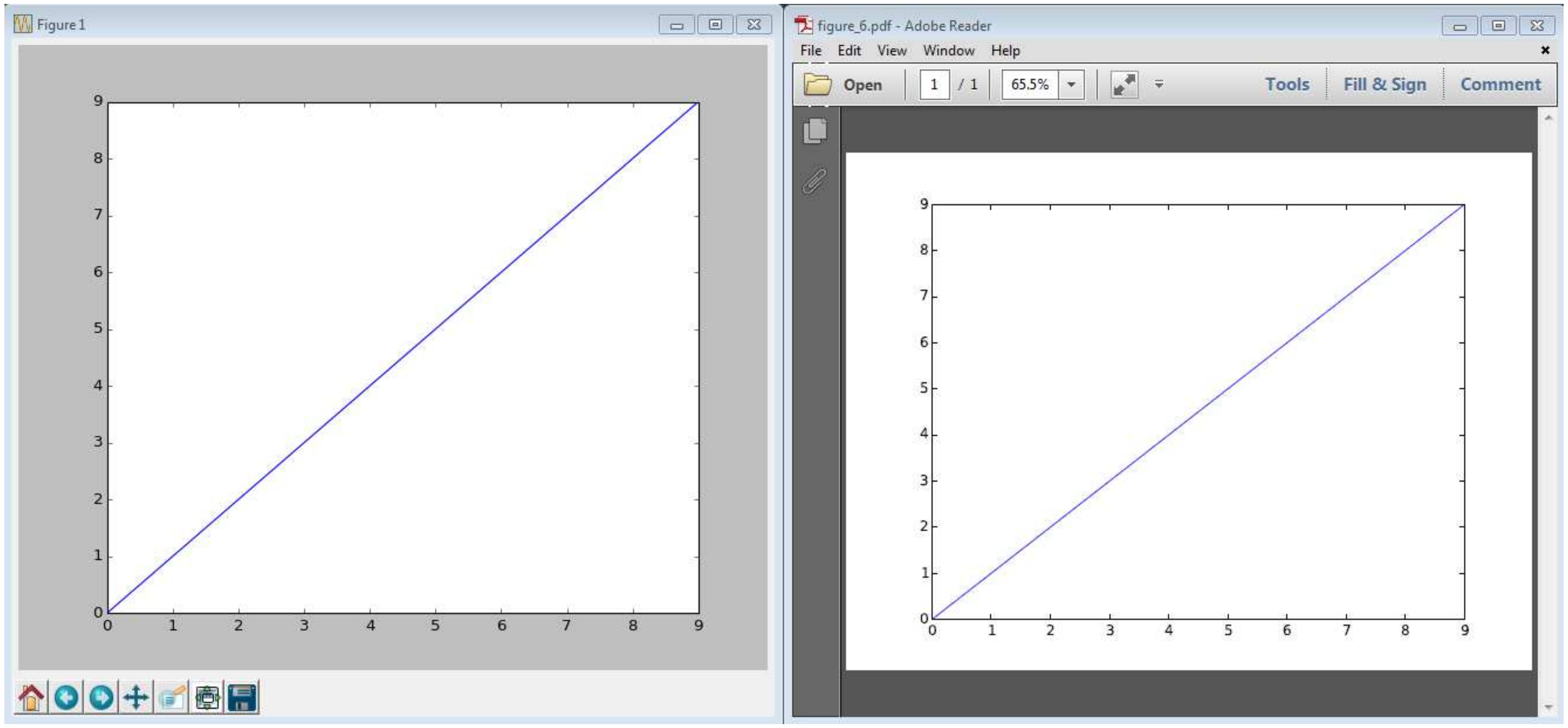
- Launch from start menu
- Click “New Notebook”
  - `In []: %pylab`
  - Or
  - `In []: %pylab inline`

Spyder

- Runs the ipython interpreter
  - Use %pylab or import
  - Nb: cannot use “Run File” with %pylab

A quick note on appearance

- In the active plot window we observe a gray border
- In the saved plot we observe a white border



Plot Generators

- There are a few functions in matplotlib that will cause a plot to be generated.
- So far we have worked with `plot(…)`.
- Now we'll look at a couple more
  - `hist(…)`
  - `scatter(…)`

Histograms

Histogram

- To plot a histogram we don’t use the function plot. We use the function hist
  - `import numpy as np`
  - `import matplotlib.pyplot as plt`
  - `plt.hist(np.random.randn(1000))`
  - `plt.show()`
- All of the tricks we just learned to manipulate the plot still work
- Here’s some examples for the binning
  - `plt.hist(np.random.randn(1000),bins=25)`
  - `plt.hist(np.random.randn(1000),bins=[-5,-4,-3,-2,-1,0,1,2,3,4,5])`

Scatter Plot

- Use the function scatter()
  - `plt.scatter(np.random.randn(1000), np.random.randn(1000))`
  - If using pylab
  - `scatter(randn(1000),randn(1000))`

plot(…)

- So far we have used a simple implementation of plot. Let’s look deeper.

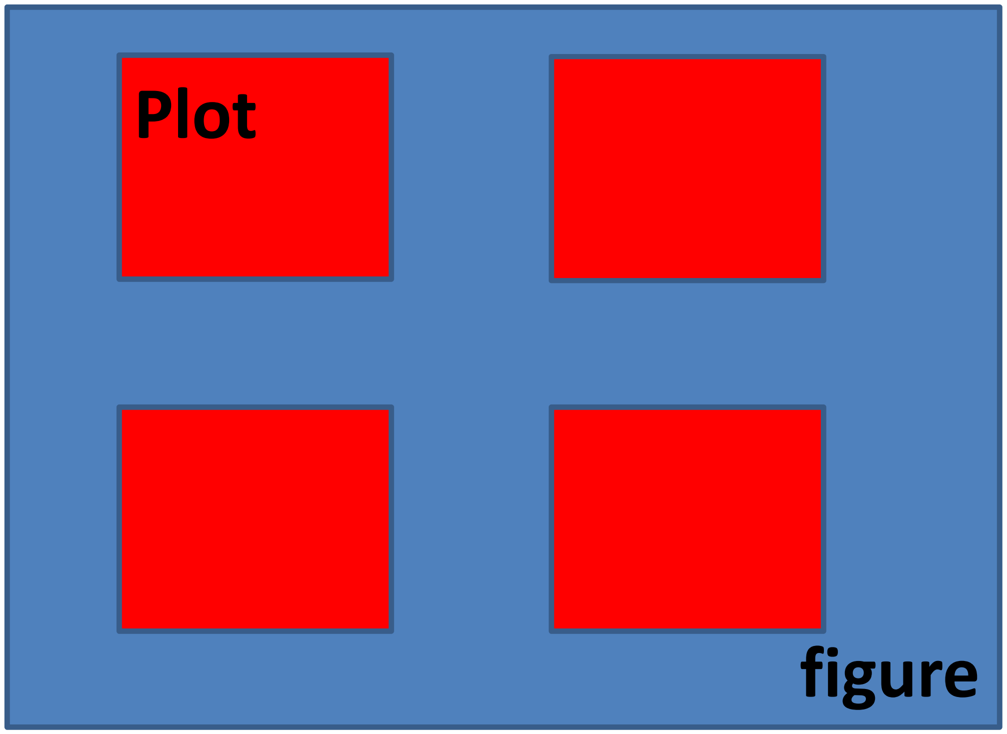
- `%pylab`
- `plot(range(10)) #generates x values`
- `clf()`
- `x=arange(0,2*pi,0.2)`
- `plot(x,sin(x))`

Multiplots

- To add multiple plots repeat the plot call
  - `%pylab`
  - `x = arange(0,2*pi,0.2)`
  - `plot1 = plot(x,sin(x))`
  - `plot2 = plot(x,cos(x))`
- Now to add a legend
  - `plot1 = plot(x,sin(x),label=‘sin’)`
  - `plot2 = plot(x,cos(x),label=‘cos’)`
  - `legend(loc=‘best’)`

Subplots

- Multiple plots in the same figure



Subplots

- For better control we will explicitly catch our objects
  - `%pylab`
  - `fig = figure()`
  - `sub1 = fig.add_subplot(2,2,1)`
  - `sub2 = fig.add_subplot(2,2,3)`
  - `plt.plot(arange(10))`
  - Use `subplot(221)` to switch active plot (demo)
- There is a function to do it all at once
  - `fig,subs = plt.subplots(3,3)`

Nb: need `plt.show()` on this one

Let’s make our plot presentable

- **C:\users\lpa2a>** `ipython --pylab`
- **In[1]:** `plot(cos(arange(0,2*pi,0.2)))`
  - Grey background
  - Axis labels too small
  - Plot touches axis
  - Plot not centered on axis
  - Horizontal axis values aren’t what we want
  - No axis labels
  - Line thickness
  - Line style

Ranges and Values

- Set axis range
  - `axis([-5,37,-1.5,1.5])`
- Change horizontal axis values
  - `x=arange(0,2*pi,0.2)`
  - `y=cos(x)`
  - `plot(x,y)`

Labels and LaTeX

- Set axis labels
  - `xlabel(‘x’,fontsize=20)`
  - `ylabel(‘cos(x)’)`
  - `title(‘Cosine’)`

- You can use LaTeX as well
  - `title(r’$\cos(x)$’)`

- `http://matplotlib.org/users/pyplot_tutorial.html`

Linestyles

- You have a lot of freedom in choosing a line style.
- They can be expressed explicitly
  - `plot(x,linestyle=‘--’)`
- The same goes for line color
  - `plot(x,color=‘g’)`
- But you can also use shorthand
  - `plot(x,’g--’)`

Linestyles II

- matplotlib automatically interpolates between the points and puts in a line. To emphasize the points you can add markers.
  - `plot(range(10),’o’)` # markers, no line
  - `plot(range(10),’o-’)` # markers, line
  - `plot(range(10),marker=‘o’)`
- Set line thickness
  - `pl = plot(arange(10))`
  - `setp(pl, linewidth=5)`

One Page to Rule them All

- http://matplotlib.org/api/pyplot_api.html
  - Comprehensive
  - Navigate with searching
  - Eg: ctrl+f ".plot("

Questions