CME 193: Introduction to Scientific Python
Lecture 5: Data Visualization

Austin Benson

Dan Frank

Institute for Computational and Mathematical Engineering (ICME)

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Homework

- Homework 4 is due Tuesday, April 23
- Homework 5 will be extra credit (in case you failed an assignment). To be posted.

Pythonic

The **pythonic** way is the simple, correct, most beautiful way of doing things.

Python style: scale function (1)

There can be beauty in brevity (and vice versa).

```
def scale(A):
    shape = A.shape
    m = shape[0]
    n = shape[1]
    for i in range(n):
        x = A[0, i]
        A[0, i] = x * 2
    for i in range(n):
        x = A[m - 1, i]
        A[m - 1, i] = x * 2
    if m < n:
        k = m
    else:
        k = n
    for i in range(k):
        x = A[i, i]
        A[i, i] = x * 5
```

Python style: scale function (2)

In general, use *=, +=, -=, etc.

```
def scale(A):
    shape = A.shape
    m = shape[0]
    n = shape[1]
    for i in range(n):
        A[0, i] *= 2
    for i in range(n):
        A[m - 1, i] *= 2
    if m < n:
        k = m
    else:
        k = n
    for i in range(k):
        A[i, i] *= 5
```

Python style: scale function (3)

Try to use the Python built-in functions (don't re-invent the wheel).

```
def scale(A):
    shape = A.shape
    m = shape[0]
    n = shape[1]
    for i in range(n):
        A[0, i] *= 2
    for i in range(n):
        A[m - 1, i] *= 2
    k = min(m, n)
    for i in range(k):
        A[i, i] *= 5
```

Python style: scale function (4)

Know the normal syntax of your data structures.

```
def scale(A):
    A[0, :] *= 2
    A[-1, :] *= 2
    shape = A.shape
    m = shape[0]
    n = shape[1]
    k = min(m, n)
    for i in range(k):
        A[i, i] *= 5
```

Python style: scale function (5)

Avoid defining too many variables.

```
def scale(A):
    A[0, :] *= 2
    A[-1, :] *= 2
    m, n = A.shape
    k = min(m, n)
    for i in range(k):
        A[i, i] *= 5
```

Python style: scale function (6)

Avoid defining too many variables...

```
def scale(A):
    A[0, :] *= 2
    A[-1, :] *= 2
    k = min(A.shape)
    for i in range(k):
        A[i, i] *= 5
```

Python style: scale function (7)

Avoid defining too many variables...

```
def scale(A):
    A[0, :] *= 2
    A[-1, :] *= 2
    k = min(A.shape)
    for i in range(k):
        A[i, i] *= 5
```

Python style: scale function (8)

Seriously, avoid defining too many variables!

```
def scale(A):
    A[0, :] *= 2
    A[-1, :] *= 2
    for i in range(min(A.shape)):
        A[i, i] *= 5
```

Python style: scale function (9)

Know a little more advanced syntax.

```
def scale(A):
    A[[0, -1], :] *= 2
    for i in range(min(A.shape)):
        A[i, i] *= 5
```

Python style: scale function (10)

Search for functions to do the work for you.

```
def scale(A):
    A[[0, -1], :] *= 2
    np.fill_diagonal(A, 5 * np.diag(A))
```

Python style: scale function

```
def scale(A):
    shape = A.shape
    m = shape[0]
    n = shape[1]
    for i in range(n):
        x = A[0, i]
        A[0, i] = x * 2
    for i in range(n):
        x = A[m-1, i]
        A[m-1, i] = x * 2
    if m<n:
        k = m
    else:
        k = n
    for i in range(k):
        x = A[i, i]
        A[i, i] = x * 5
```

Do not be afraid to re-write code!

```
def scale(A):
    A[[0, -1], :] *= 2
    np.fill_diagonal(A, 5 * np.diag(A))
```

A lesson in Python style

Matlab and SciPy

matplotlib

.mat files

- "I want to use Matlab because all my data is in .mat format" -ICME colleague

- `scipy.io.loadmat()` and `scipy.io.savemat()`

plotting

- “I like Matlab’s plotting” -Me (a while ago)
- `matplotlib.pyplot` “Provides a MATLAB-like plotting framework.”
  -`http://matplotlib.org/api/pyplot_api.html`

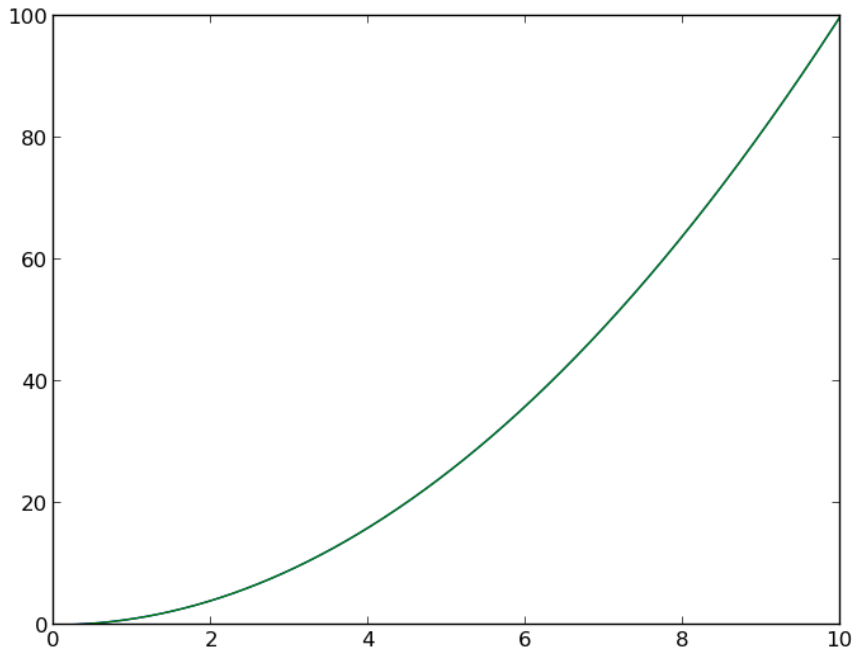
What is Matplotlib?

matplotlib.org: matplotlib is a python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms. matplotlib can be used in python scripts, the python and ipython shell (ala MATLAB or Mathematica), web application servers, and six graphical user interface toolkits.

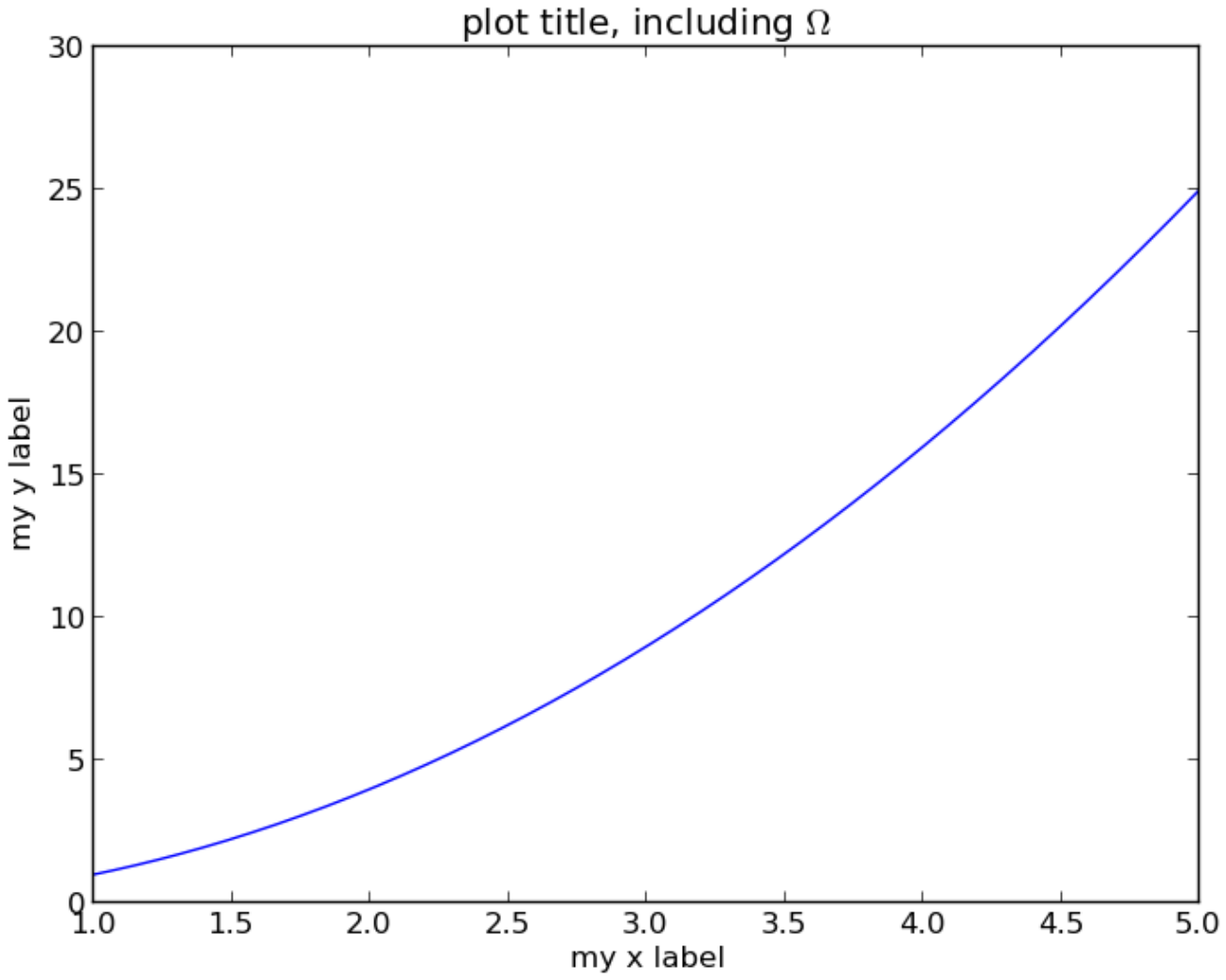
- matplotlib is the standard Python plotting library
- We will prmarily be using `matplotlib.pyplot` for data analysis
- Can create histograms, power spectra, bar charts, errorcharts, scatterplots, etc with a few lines of code

Line Plot

```
import numpy as np
import matplotlib.pyplot as plt

x = np.linspace(0, 10, 1000)
y = np.power(x, 2)
plt.plot(x, y)
plt.savefig('line_plot.png')
```



Line Plot+

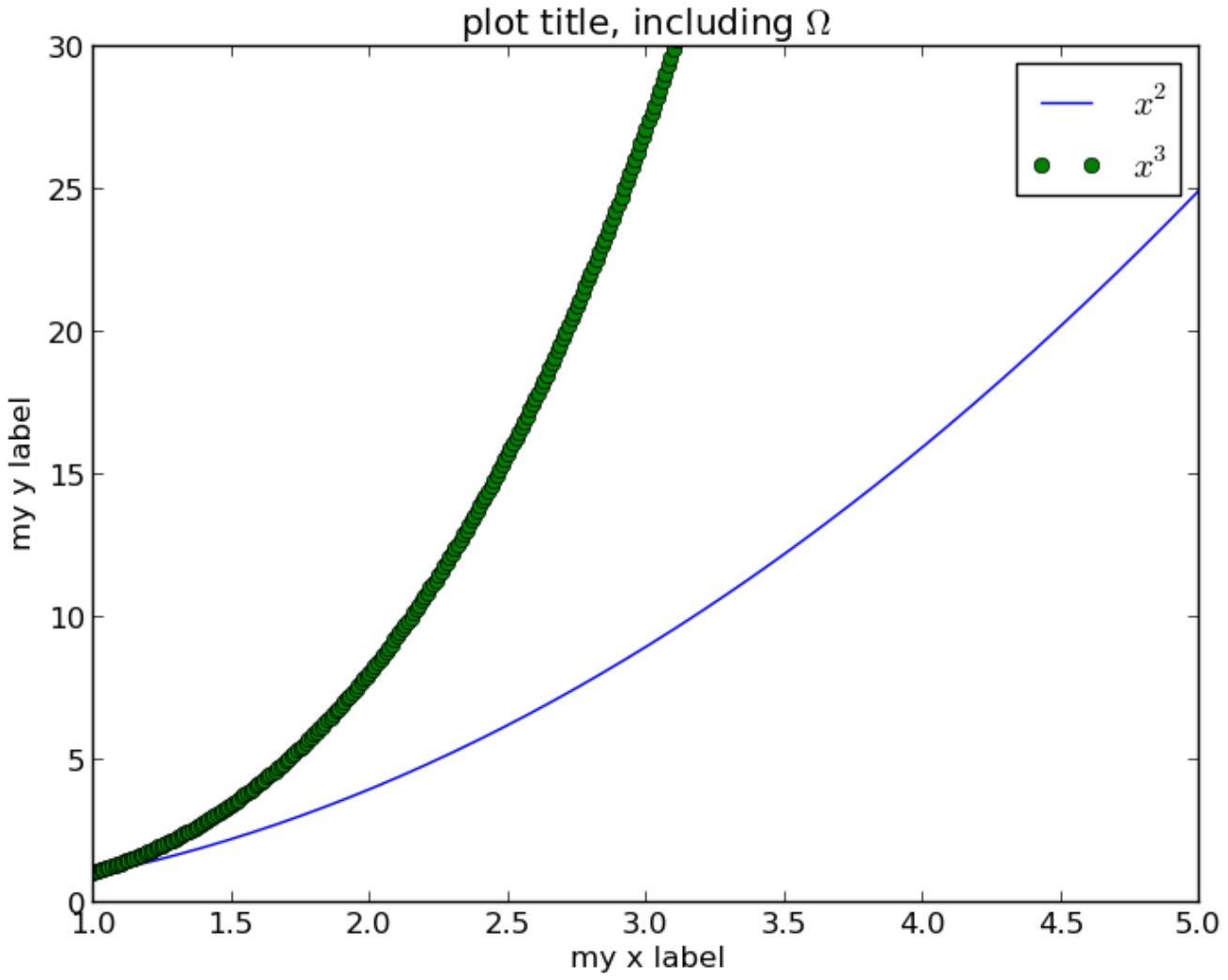

plot title, including Ω
my y label
my x label
0
5
10
15
20
25
30
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

Line Plot+

Adding titles and labels

```
import numpy as np
import matplotlib.pyplot as plt

x = np.linspace(0, 10, 1000)
y = np.power(x, 2)
plt.plot(x, y)
plt.xlim((1, 5))
plt.ylim((0, 30))
plt.xlabel('my x label')
plt.ylabel('my y label')
plt.title('plot title, including $\Omega$')

plt.savefig('line_plot_plus.png')
```

Line Plot++

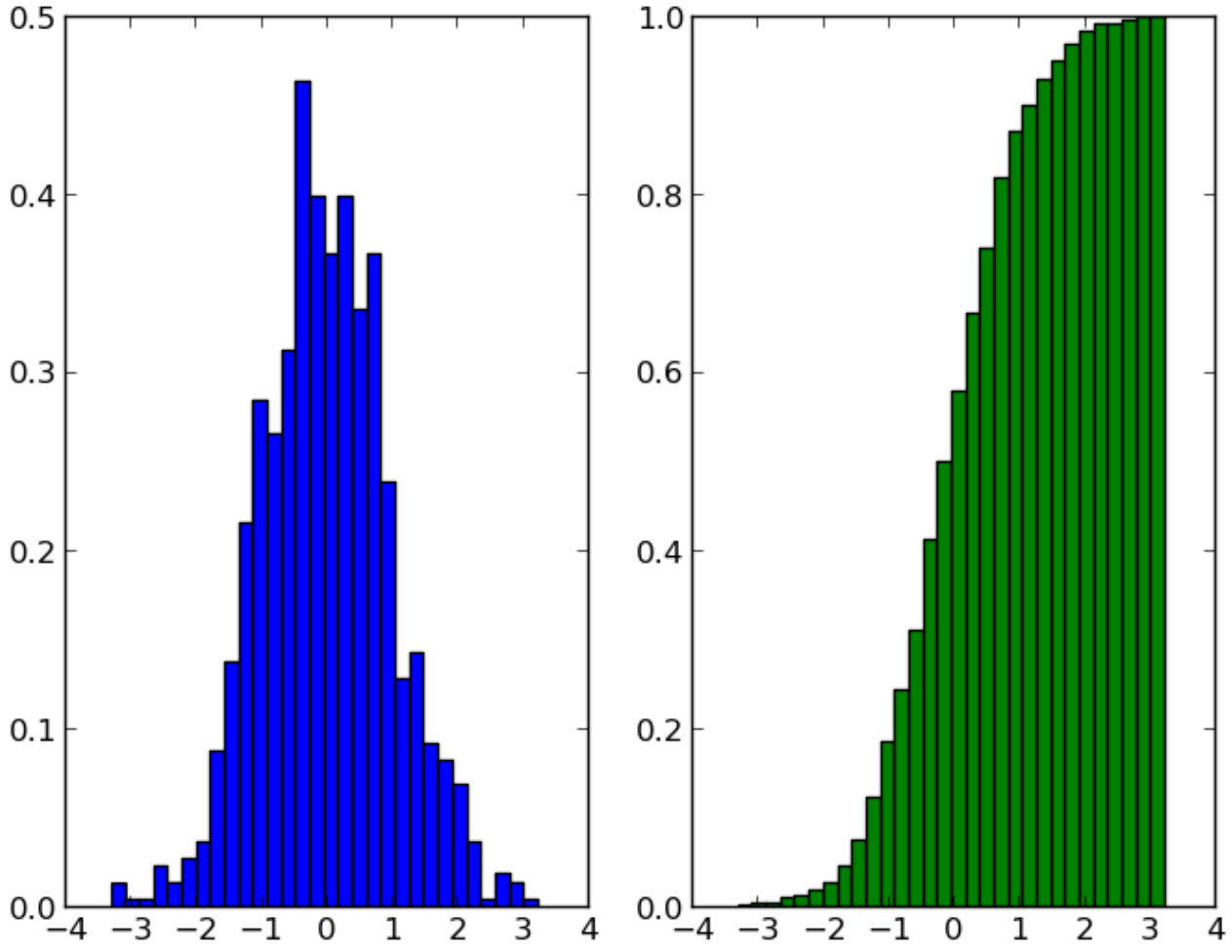

plot title, including Ω
my y label
my x label
x^2
x^3
0
5
10
15
20
25
30
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

Scatter Plot++

Adding multiple lines and a legend

```
import numpy as np
import matplotlib.pyplot as plt

x = np.linspace(0, 10, 1000)
y1 = np.power(x, 2)
y2 = np.power(x, 3)

plt.plot(x, y1, 'b-', x, y2, 'go')
plt.xlim((1, 5))
plt.ylim((0, 30))
plt.xlabel('my x label')
plt.ylabel('my y label')
plt.title('plot title, including $\Omega$')
plt.legend(('$x^2$', '$x^3$'))

plt.savefig('line_plot_plus2.png')
```

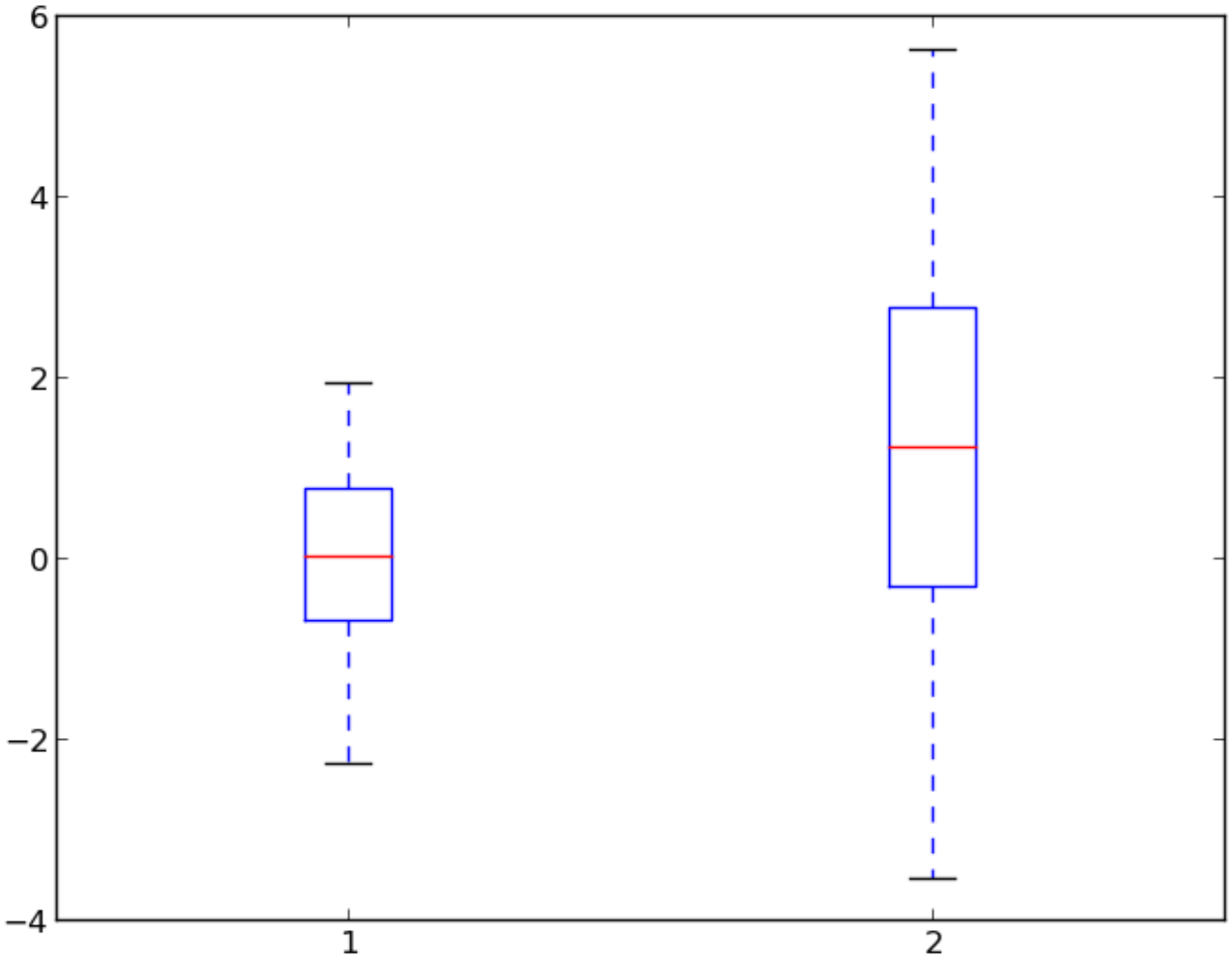
Histogram



Histogram

```
import numpy as np
import matplotlib.pyplot as plt

data = np.random.randn(1000)

# histogram (pdf)
plt.subplot(1, 2, 1)
plt.hist(data, bins=30, normed=True, facecolor='b')

# empirical cdf
plt.subplot(1, 2, 2)
plt.hist(data, bins=30, normed=True, color='g',
         cumulative=True)

plt.savefig('histogram.png')
```

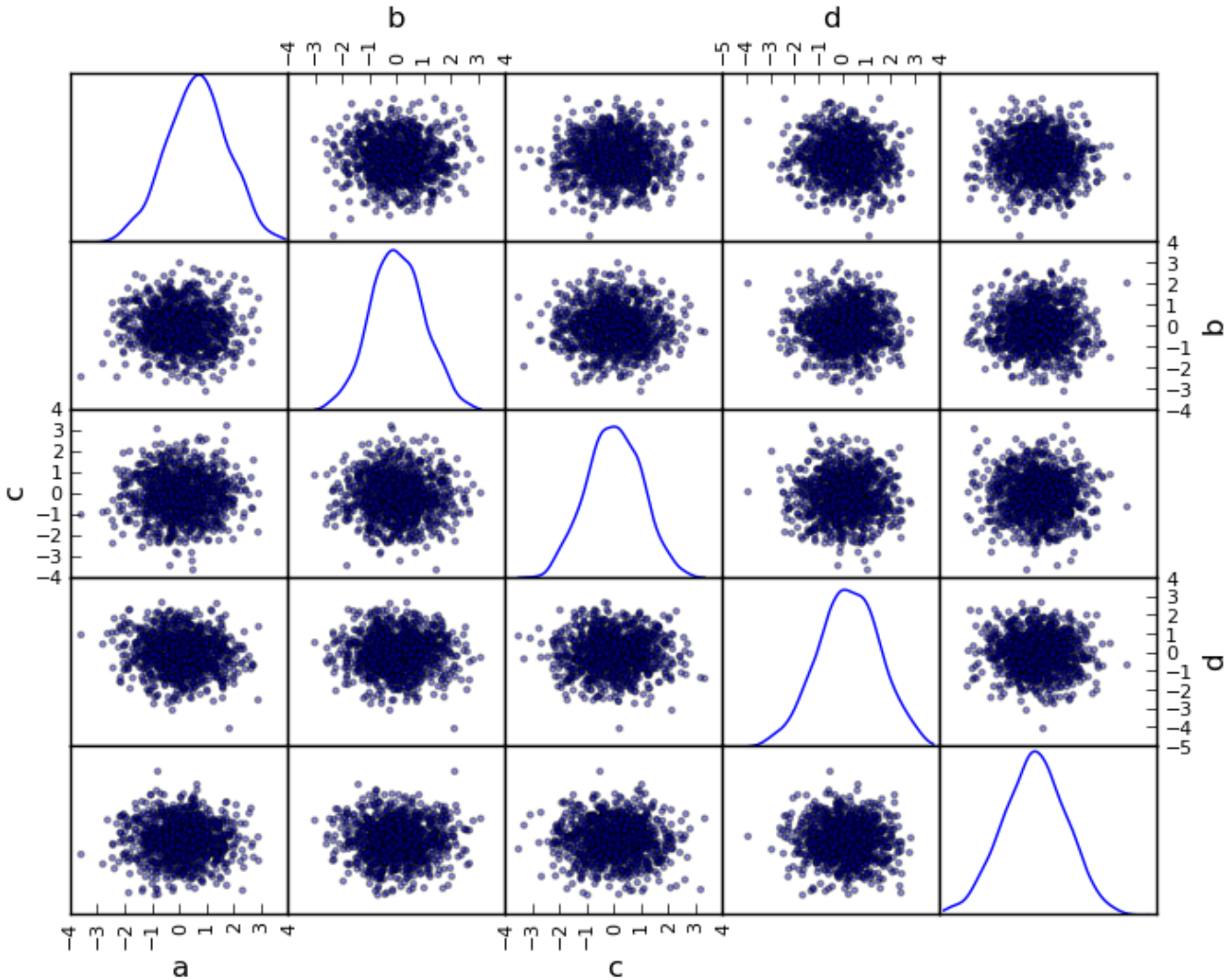
Box Plot



Box Plot

```
import numpy as np
import matplotlib.pyplot as plt

samp1 = np.random.normal(loc=0., scale=1., size=100)
samp2 = np.random.normal(loc=1., scale=2., size=100)

plt.boxplot((samp1, samp2))
plt.savefig('boxplot.png')
```

Scatter Plot Matrix



Scatter Plot Matrix

`matplotlib` doesn't have everything, especially functions that are designed to act on more than one axis at once.

```
import matplotlib.pyplot as plt
import numpy as np
from pandas.tools.plotting import scatter_matrix
from pandas import DataFrame

df = DataFrame(np.random.normal(loc=0.,
                                scale=1.,
                                size=(1000, 5)),
               columns=['a', 'b', 'c', 'd', 'e'])
scatter_matrix(df, alpha=0.4, diagonal='kde')

plt.savefig('scattermatrix.png')
```

Scatter Plot Matrix

The Debian VM has pandas installed (Python data analysis library)

Image Plot

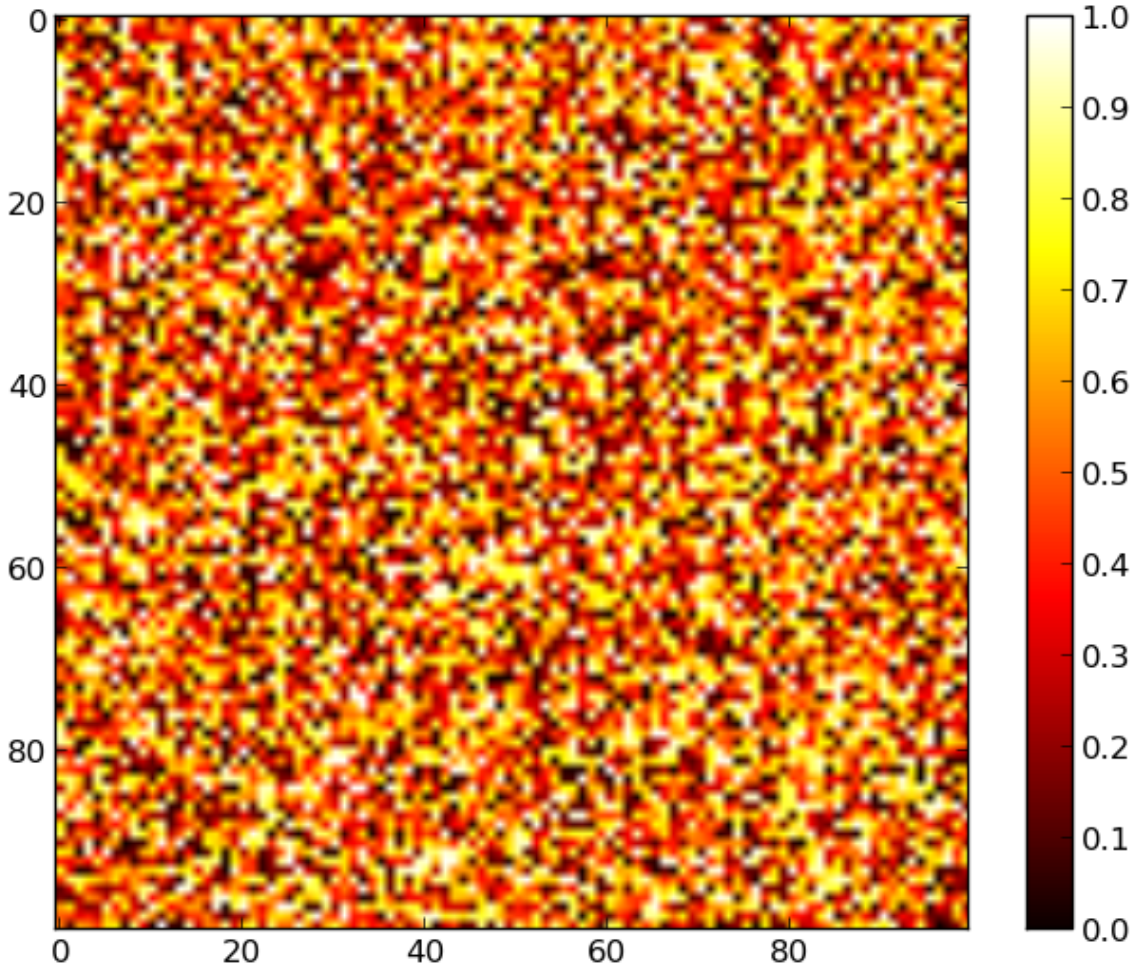
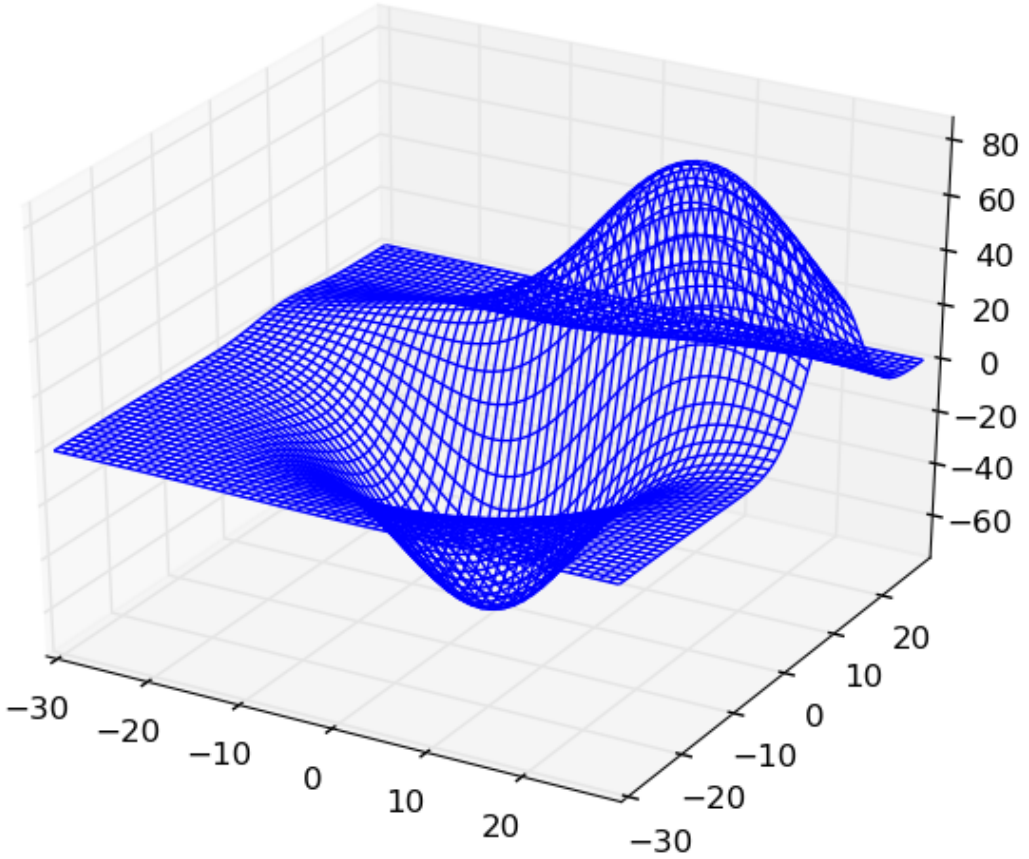


Image Plot

```
import numpy as np
import matplotlib.pyplot as plt

A = np.random.random((100, 100))
plt.imshow(A)
plt.hot()
plt.colorbar()

plt.savefig('imageplot.png')
```

Wire Plot



Wire Plot

matplotlib toolkits extend funtionality for other kinds of visualization

```
from mpl_toolkits.mplot3d import axes3d
import matplotlib.pyplot as plt

ax = plt.subplot(111, projection='3d')
X, Y, Z = axes3d.get_test_data(0.1)
ax.plot_wireframe(X, Y, Z)

plt.savefig('wire.png')
```

End

- Thanks for a great class!
- Please provide feedback (online material, homework, etc.)
- End-of-quarter course surveys