

## Live Demo

Let's implement a function that returns the  $n$ th element of a certain series.

The first two elements of the series are given:

$$F_0 = 1, F_1 = 1$$

The function returns  $F_n$  such that:

$$F_n = F_{n-2} + F_{n-1}$$

In [13]:

```
def fibonacci(n):
    if 0 <= n <= 1:
        return 1
    else:
        return fibonacci(n - 2) + fibonacci(n - 1)

# check
print fibonacci(0), fibonacci(1), fibonacci(2)

# check again
print
for n in range(10):
    print n, fibonacci(n)

# plotting
%matplotlib inline
x = range(10)
y = [fibonacci(n) for n in x]

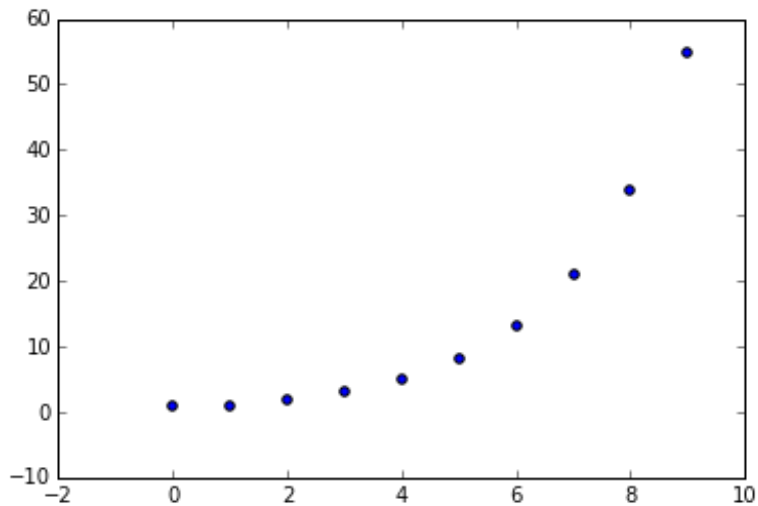
import matplotlib.pyplot as plt
plt.scatter(x, y)
```

1 1 2

0 1  
1 1  
2 2  
3 3  
4 5  
5 8  
6 13  
7 21  
8 34  
9 55

Out[13]:

<matplotlib.collections.PathCollection at 0x1067b7b90>



## NumPy

NumPy provides the *ndarray* object, which implements an efficient homogeneous multi-dimensional array type.

In [14]:

```
import numpy as np

A = np.arange(6.).reshape(3, 2)
B = np.array([1, 0])

# element-wise
C = A * B

# matrix multiplication
D = np.dot(A, B)
```

See how fast it finds the maximum among a 1 million cells.

In [15]:

```
np.random.seed(1234)

print "numpy.ndarray"
M = np.random.rand(1000, 1000)
%time M.max()

print "\nlist"
M2 = [M[i,j] for i in xrange(1000) for j in xrange(1000)]
%time max(M2)
```

```
numpy.ndarray
CPU times: user 581 µs, sys: 0 ns, total: 581 µs
Wall time: 592 µs
```

```
list
CPU times: user 29.6 ms, sys: 1.45 ms, total: 31 ms
```

```
CPU times: user 1.176 ms, sys 1.176 ms, total 2.352 ms  
Wall time: 31 ms
```

Out[15]:

```
0.999999912003261893
```

NumPy has many built-in functions, for instance, Singular Value Decomposition can be as simple as:

In [16]:

```
a = np.random.randn(9, 6)  
U, s, V = np.linalg.svd(a)  
print U.shape, s.shape, V.shape
```

```
# check  
S = np.zeros((9, 6))  
S[:6, :6] = np.diag(s)  
aa = np.dot(U, np.dot(S, V))  
np.allclose(a, aa)
```

```
(9, 9) (6,) (6, 6)
```

Out[16]:

```
True
```

## SciPy libraries

An example from scipy.optimize module. Minimizing the Rosenbrock function of N variables:

$$f(\mathbf{x}) = \sum_{i=1}^{N-1} 100(x_i - x_{i-1}^2)^2 + (1 - x_{i-1})^2.$$

The minimum value of this function is 0 which is achieved when  $x_i = 1$ .

In [17]:

```
import numpy as np  
from scipy.optimize import minimize  
  
def rosen(x):  
    return sum(100.0*(x[1:] - (x[:-1])**2.0)**2.0 + (1-x[:-1])**2.0)  
  
# using simplex method  
x0 = np.array([1.3, 0.7, 0.8, 1.9, 1.2])  
res = minimize(rosen, x0, method='nelder-mead', options={'xtol':1e-8, 'disp':  
True})  
print res.x
```

Optimization terminated successfully.

Current function value: 0.000000

Iterations: 339

Function evaluations: 571

```
[ 1.  1.  1.  1.  1.]
```

## R interface

From <http://tinyurl.com/mf5m5ey>. Requires R and rpy2 python module being already installed. (Rmagic is now a part of rpy2.)

In [18]:

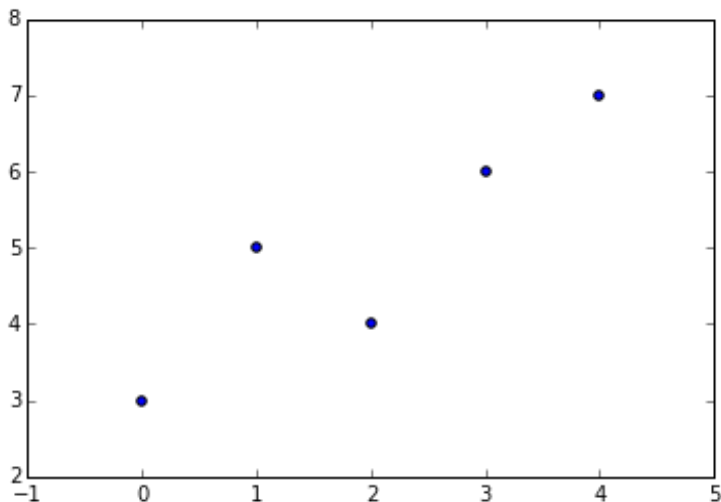
```
%matplotlib inline
%load_ext rpy2.ipython

import matplotlib.pyplot as plt

X = np.array(xrange(5))
Y = np.array([3, 5, 4, 6, 7])
plt.scatter(X, Y)
```

Out[18]:

<matplotlib.collections.PathCollection at 0x10f8ef690>



In [19]:

```
%Rpush X Y
%R lm(Y ~ X)$coef
```

Out[19]:

<FloatVector - Python:0x10f8a4830 / R:0x10d00bd80>  
[3.200000, 0.900000]

In [20]:

```
# check the coef's in python
Xr = X - X.mean()
Yr = Y - Y.mean()
slope = (Xr * Yr).sum() / (Xr**2).sum()
intercept = Y.mean() - X.mean() * slope
print "{0:.1f}, {1:.1f}".format(intercept, slope)
```

3.2, 0.9

In [21]:

```
a = %R resid(lm(Y ~ X))  
print a
```

1	2	3	4	5
-0.2	0.9	-1.0	0.1	0.2