Exercise4 SciPy

April 15, 2018

1 SciPy

The SciPy library is one of the core packages that make up the SciPy stack. It provides many user-friendly and efficient numerical routines such as routines for numerical integration and optimization.

Library documentation: http://www.scipy.org/scipylib/index.html

1.1 Task1

What is t-test? See example in the end of the document

1.1.1 Answer:

The t test compares two means and tells if they are different from each other. The t test also tells how significant the differences are; In other words it lets us know if those differences could have happened by chance.

In [4]:
```
# needed to display the graphs
%matplotlib inline
from pylab import *
```

In [5]:
```
from numpy import *
from scipy.integrate import quad, dblquad, tplquad
```

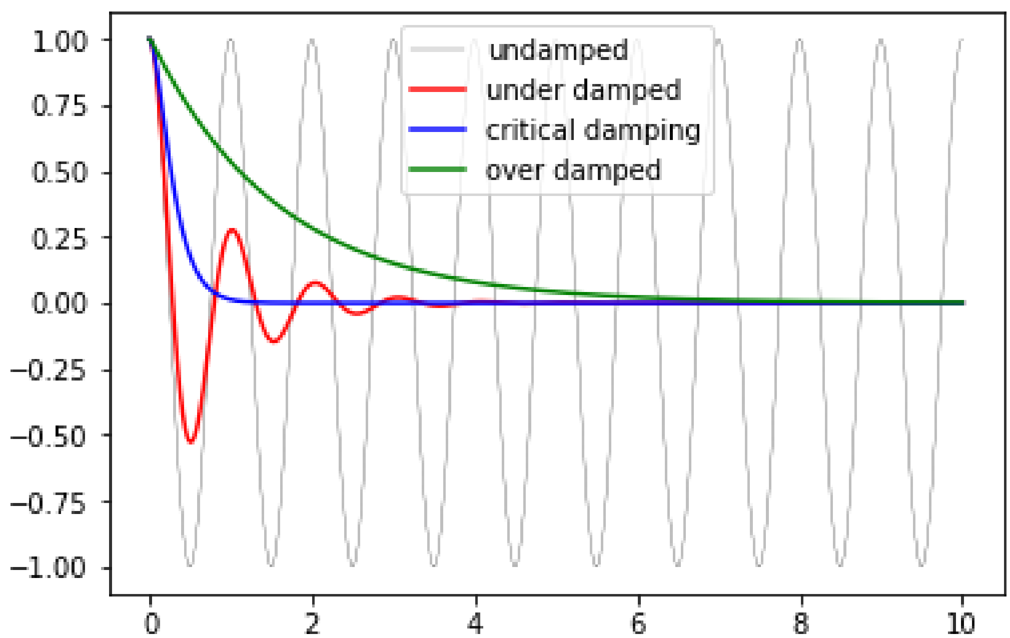
In [6]:
```
# integration
val, abserr = quad(lambda x: exp(-x ** 2),  Inf, Inf)
val, abserr
```

Out[6]:
```
(0.0, 0.0)
```

In [7]:
```
from scipy.integrate import odeint, ode
```

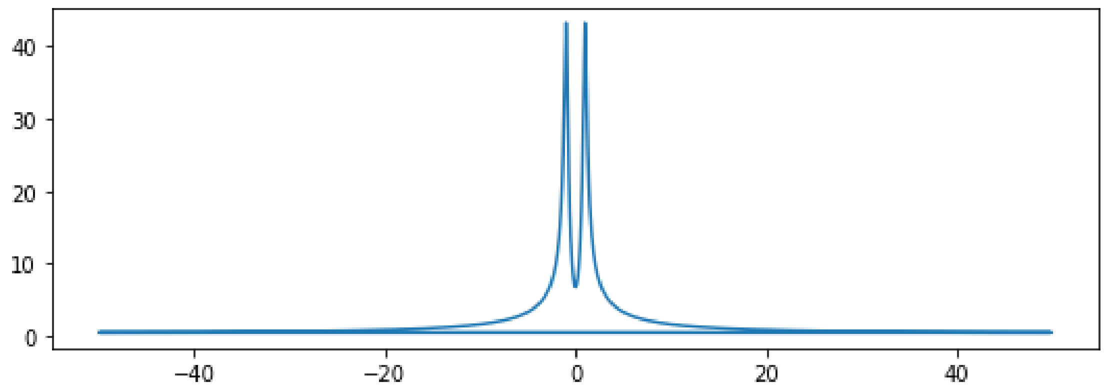
In [8]:
```
# differential equation
def dy(y, t, zeta, w0):
    x, p = y[0], y[1]
```

```python
    dx = p
    dp = -2 * zeta * w0 * p - w0**2 * x

    return [dx, dp]

# initial state
y0 = [1.0, 0.0]

# time coodinate to solve the ODE for
t = linspace(0, 10, 1000)
w0 = 2*pi*1.0

# solve the ODE problem for three different values of the damping ratio
y1 = odeint(dy, y0, t, args=(0.0, w0)) # undamped
y2 = odeint(dy, y0, t, args=(0.2, w0)) # under damped
y3 = odeint(dy, y0, t, args=(1.0, w0)) # critial damping
y4 = odeint(dy, y0, t, args=(5.0, w0)) # over damped

fig, ax = subplots()
ax.plot(t, y1[:,0], 'k', label="undamped", linewidth=0.25)
ax.plot(t, y2[:,0], 'r', label="under damped")
ax.plot(t, y3[:,0], 'b', label=r"critical damping")
ax.plot(t, y4[:,0], 'g', label="over damped")
ax.legend();
```




```python
In [9]: from scipy.fftpack import *
```

```
In [10]: # fourier transform
         N = len(t)
         dt = t[1]-t[0]

         # calculate the fast fourier transform
         # y2 is the solution to the under-damped oscillator from the previous section
         F = fft(y2[:,0])

         # calculate the frequencies for the components in F
         w = fftfreq(N, dt)

         fig, ax = subplots(figsize=(9,3))
         ax.plot(w, abs(F));
```



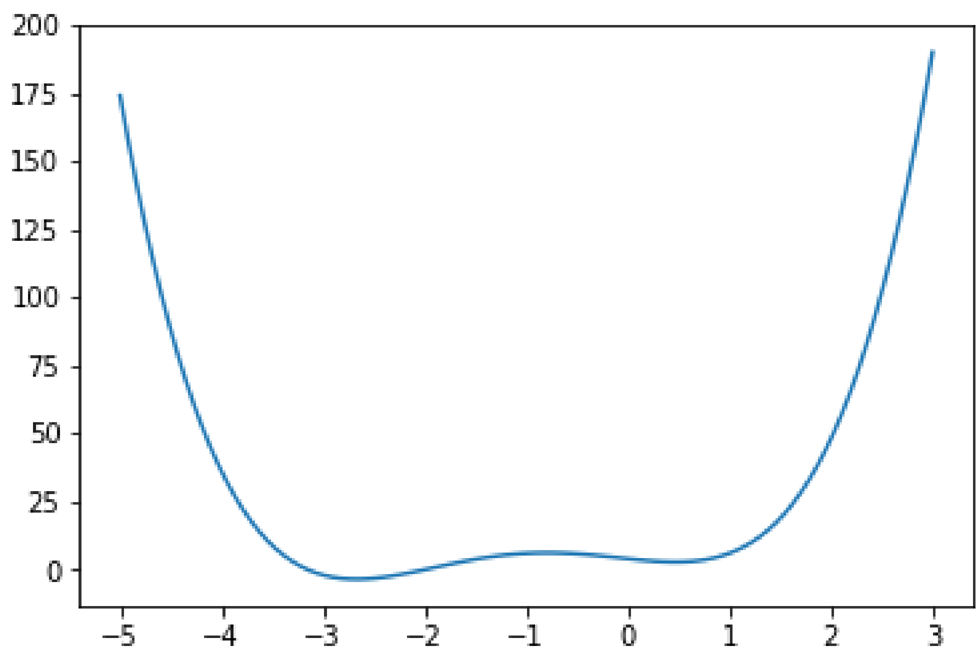
1.1.2 Linear Algebra

```
In [11]: A = array([[1,2,3], [4,5,6], [7,8,9]])
         b = array([1,2,3])

In [12]: # solve a system of linear equations
         x = solve(A, b)
         x

Out[12]: array([-0.23333333,  0.46666667,  0.1        ])

In [13]: # eigenvalues and eigenvectors
         A = rand(3,3)
         B = rand(3,3)

         evals, evecs = eig(A)

         evals

Out[13]: array([ 1.63745179, -0.27099717,  0.29221869])
```

```
In [14]: evecs

Out[14]: array([[ 0.52266728,  0.89586684,  0.0465981 ],
                [ 0.75282179, -0.40859634, -0.66157783],
                [ 0.40009781, -0.17456128,  0.74842727]])

In [15]: svd(A)

Out[15]: (array([[-0.54649945, -0.56455691,  0.61855787],
                 [-0.72419462,  0.68951555, -0.01051025],
                 [-0.42057163, -0.45370013, -0.78566894]]),
          array([1.67154471, 0.33921771, 0.22868873]),
          array([[-0.4132404 , -0.71035796, -0.56975779],
                 [ 0.60139999,  0.25692064, -0.75651162],
                 [-0.68377659,  0.6552735 , -0.32103928]]))
```

1.1.3 Optimization

```
In [16]: from scipy import optimize

In [17]: def f(x):
             return 4*x**3 + (x-2)**2 + x**4

         fig, ax  = subplots()
         x = linspace(-5, 3, 100)
         ax.plot(x, f(x));
```



In [18]:
```
x_min = optimize.fmin_bfgs(f, -0.5)
x_min
```

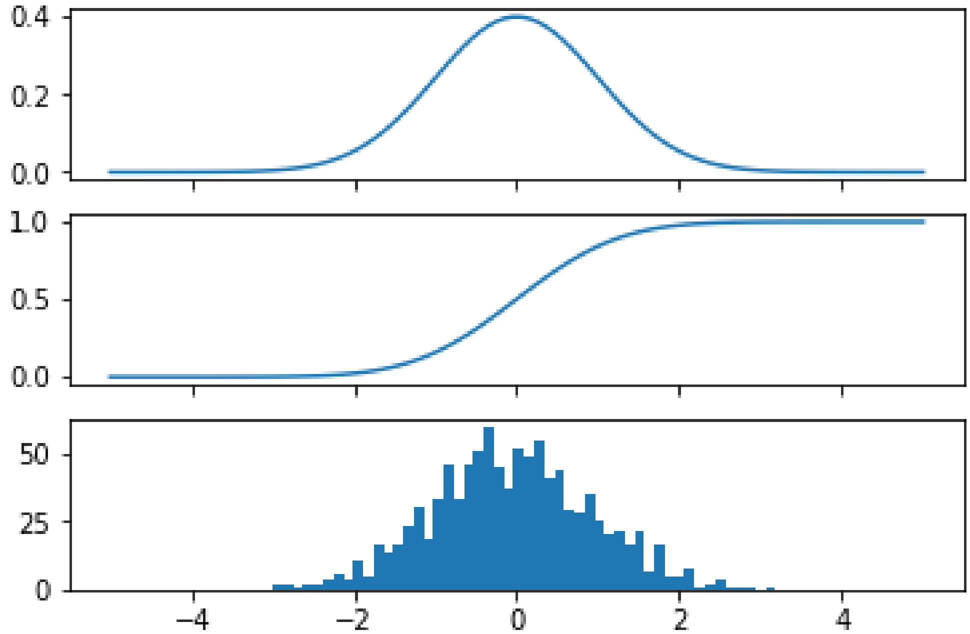
```
Optimization terminated successfully.
         Current function value: 2.804988
         Iterations: 4
         Function evaluations: 18
         Gradient evaluations: 6
```

Out[18]:
```
array([0.46961743])
```

1.1.4 Statistics

In [19]:
```
from scipy import stats
```

In [20]:
```
# create a (continous) random variable with normal distribution
Y = stats.norm()

x = linspace(-5,5,100)

fig, axes = subplots(3,1, sharex=True)

# plot the probability distribution function (PDF)
axes[0].plot(x, Y.pdf(x))

# plot the commulative distributin function (CDF)
axes[1].plot(x, Y.cdf(x));

# plot histogram of 1000 random realizations of the stochastic variable Y
axes[2].hist(Y.rvs(size=1000), bins=50);
```



In [21]:
```
Y.mean(), Y.std(), Y.var()
```

Out[21]:
```
(0.0, 1.0, 1.0)
```

In [22]:
```
# t-test example
t_statistic, p_value = stats.ttest_ind(Y.rvs(size=1000), Y.rvs(size=1000))
t_statistic, p_value
```

Out[22]:
```
(-1.5051954859504642, 0.1324318875388194)
```