Exercise4 SciPy

April 14, 2018

1 Hochschule Bonn-Rhein-Sieg

2 Learning and Adaptivity, SS18

3 Assignment 01 (15-April-2018)

3.1 Sathiya Ramesh, Pradheep Krishna Muthukrishnan Padmanabhan, Naresh Kumar Gurulingan

4 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.

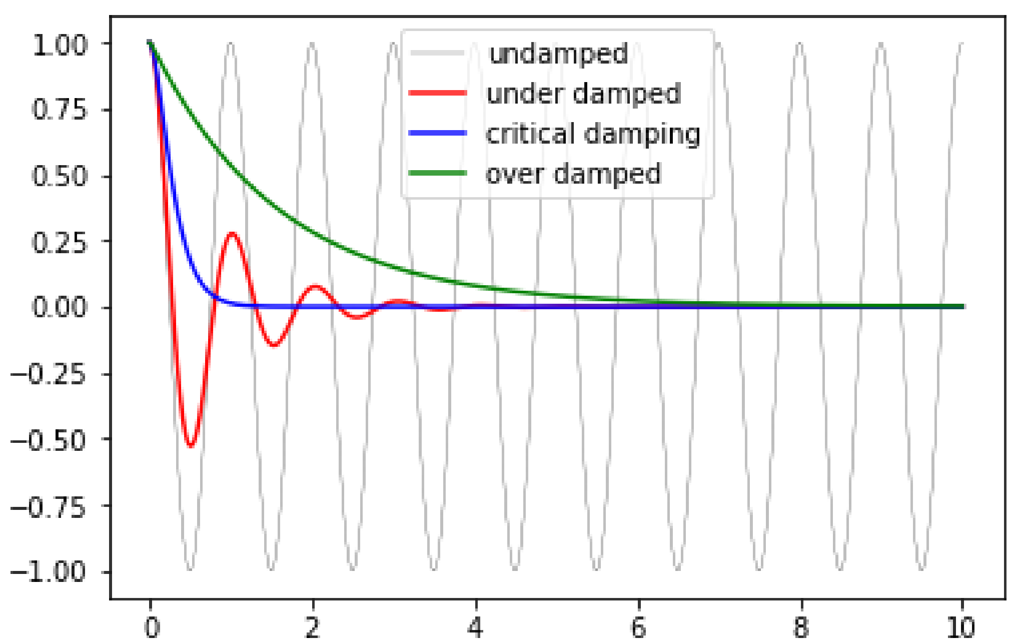
Library documentation: http://www.scipy.org/scipylib/index.html

4.1 Task1

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

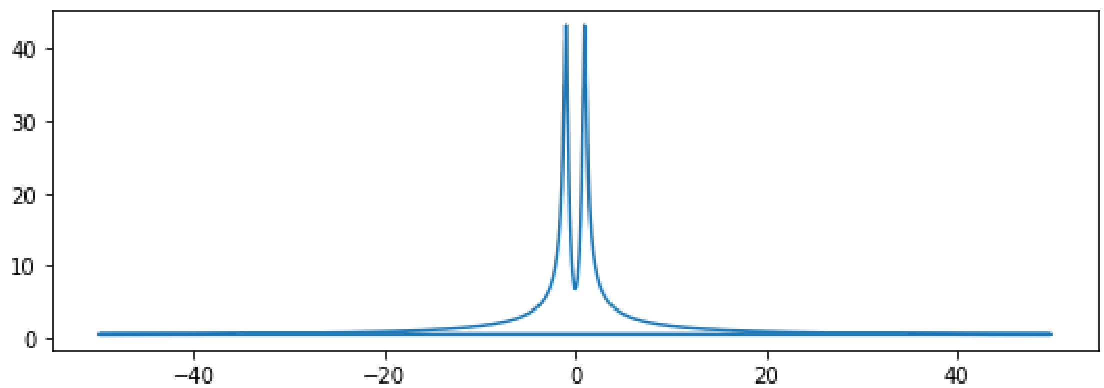
```
In [1]: # needed to display the graphs
        %matplotlib inline
        from pylab import *

In [2]: from numpy import *
        from scipy.integrate import quad, dblquad, tplquad

In [3]: # integration
        val, abserr = quad(lambda x: exp(-x ** 2),  Inf, Inf)
        val, abserr

Out[3]: (0.0, 0.0)

In [4]: from scipy.integrate import odeint, ode

In [5]: # differential equation
        def dy(y, t, zeta, w0):
            x, p = y[0], y[1]
```

```
    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();
```



In [6]:
```
from scipy.fftpack import *
```

In [7]:
```
# 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));
```



4.1.1 Linear Algebra

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

In [9]:
```
# solve a system of linear equations
x = solve(A, b)
x
```

Out[9]:
```
array([-0.23333333,  0.46666667,  0.1       ])
```

In [10]:
```
# eigenvalues and eigenvectors
A = rand(3,3)
B = rand(3,3)

evals, evecs = eig(A)

evals
```

```
Out[10]: array([ 1.53141394+0.        j, -0.30073306+0.01693434j,
               -0.30073306-0.01693434j])
```

```
In [11]: evecs
```

```
Out[11]: array([[ 0.62642903+0.        j,  0.2369939 +0.02930752j,
                  0.2369939 -0.02930752j],
                [ 0.39083337+0.        j,  0.27368498-0.04534046j,
                  0.27368498+0.04534046j],
                [ 0.67441527+0.        j, -0.93059967+0.        j,
                 -0.93059967-0.        j]])
```

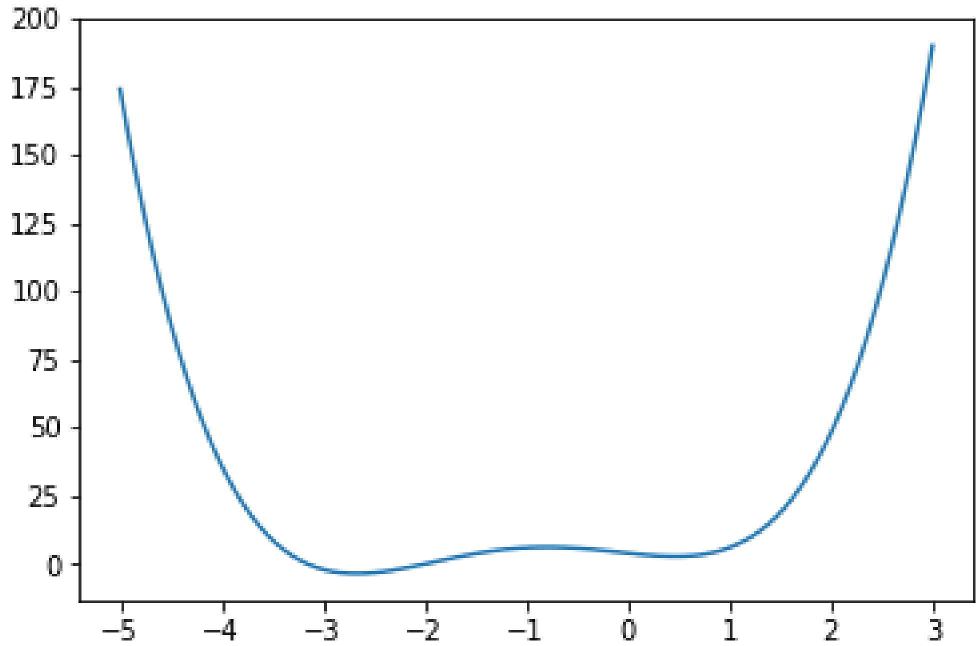
```
In [12]: svd(A)
```

```
Out[12]: (array([[-0.58499244, -0.12700336, -0.80103308],
                [-0.34253315, -0.85656668,  0.38595928],
                [-0.73515637,  0.50016365,  0.45758217]]),
          array([1.70639751, 0.46280173, 0.17593598]),
          array([[-0.75462467, -0.59293227, -0.28102123],
                [-0.47124877,  0.78776387, -0.39667704],
                [ 0.45658099, -0.16691138, -0.87388466]]))
```

4.1.2 Optimization

```
In [13]: from scipy import optimize
```

```
In [14]: 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));
```

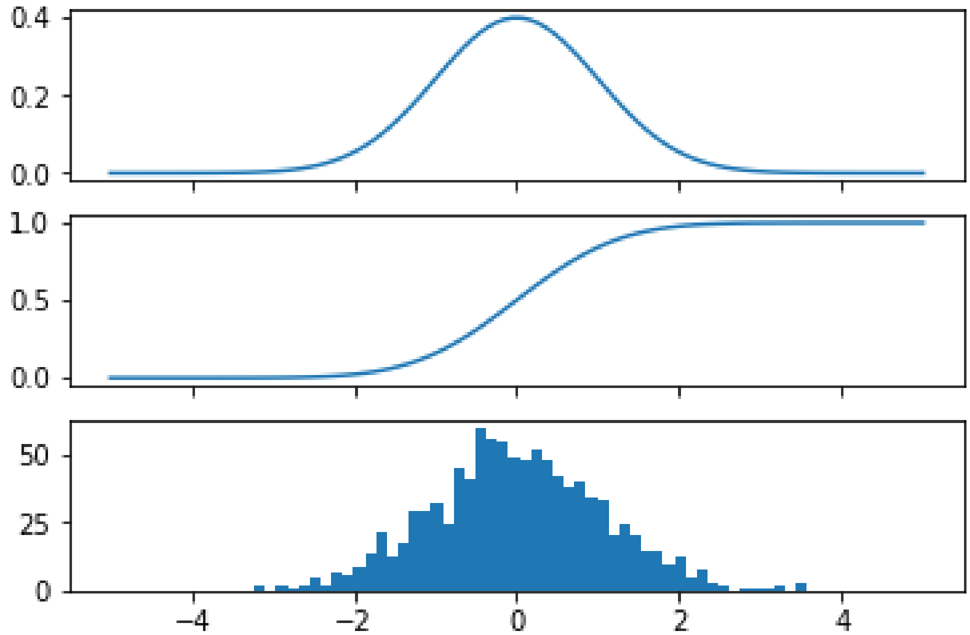



```
In [15]: x_min = optimize.fmin_bfgs(f, -0.5)
         x_min

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


Out[15]: array([0.46961743])
```

4.1.3 Statistics

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

In [17]: # 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 [18]:
```
Y.mean(), Y.std(), Y.var()
```

Out[18]:
```
(0.0, 1.0, 1.0)
```

In [19]:
```
# t-test example
t_statistic, p_value = stats.ttest_ind(Y.rvs(size=1000), Y.rvs(size=1000))
t_statistic, p_value
```

Out[19]:
```
(0.23912536205282356, 0.8110329013998367)
```