MCRand

Release 0.0.1

Sep 21, 2020

Contents

CHAPTER 1

Installation

Install the library with pip:

```
$ pip install mcrand
```

CHAPTER 2

Samples

2.1 Random Number Generator

Here you can find a comparison between MCRand and Numpy for different probability distributions. Moreover, we use the program to generate random samples drawn from non-standard distributions.

To use the MCRand library to generate random numbers we first need to import the random generator (RandGen). This step can be done in the following way

```
from mcrand import sample
```

2.1.1 Gaussian distribution

To generate gaussian distributed numbers with the MCRand random generator we first need to define the Gaussian PDF

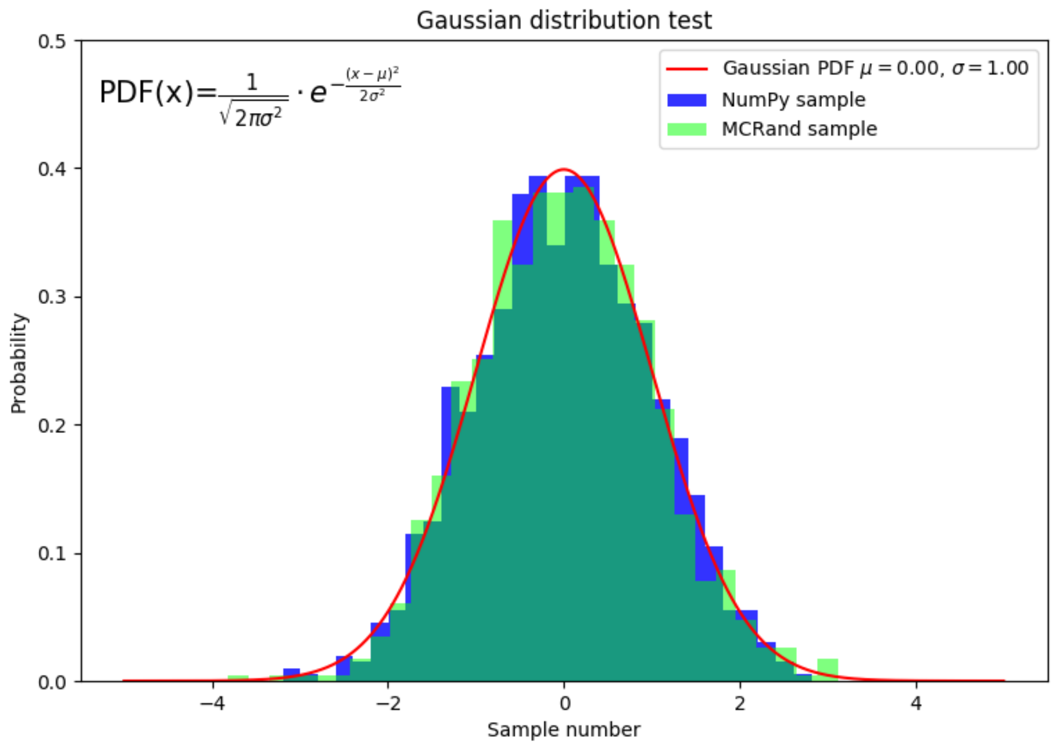
```
def gaussian(x, mu, sigma):
        return (1/(np.sqrt(2*np.pi*sigma**2))) * np.exp(-(x-mu)**2/(2*sigma**2))
```

Then, MCRand can be used to generate `N` gaussian numbers from `x0` to `xf` as follows

```
x0 = -5
xf = 5
N = 1000

sigma = 1
mu = 0

gaussian_sample = sample(gaussian, x0, xf, N, mu, sigma)
```

Finally to plot the histogram and the PDF we can use `matplotlib.pyplot`

```
import matplotlib.pyplot as plt

plt.hist(gaussian_sample, bins=30, density=True, color=(0,1,0,0.5), label='MCRand␣
↪sample')
plt.plot(x, gaussian(x, mu, sigma), color='r', label=r'Gaussian PDF $\mu=%.2f$,
↪$\sigma=%.2f$' % (mu,sigma))
```



Gaussian distribution with Numpy and MCRand

2.1.2 Cauchy distribution

To generate a Cauchy distribution we need to define its PDF

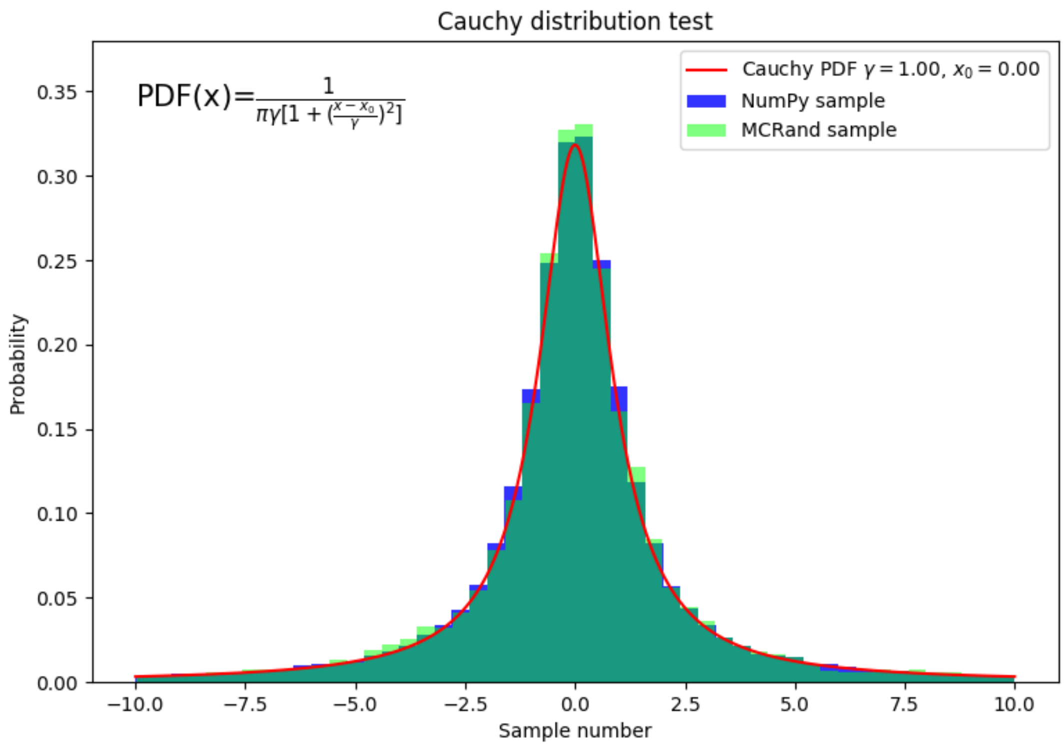
```
def cauchy(x, x0, gamma):
        return 1 / (np.pi * gamma * (1 + ((x-x0)/(gamma))**2))
```

and then use the random number generator of MCRand as before

```

x0 = -10
xf = 10
N = 10**5

x0_cauchy = 0
gamma = 1

cauchy_sample = sample(gaussian, x0, xf, N, mu, sigma)
```

Finally we plot the histogram and the PDF

```
plt.hist(cauchy_sample, bins=50, density=True, color=(0,1,0,0.5), label='MCRand sample
↪')
plt.plot(x, cauchy(x, x0_cauchy, gamma), color='r', label=r'Cauchy PDF $\gamma=%.2f$,
↪$x_0=%.2f$' % (gamma, x0_cauchy))
```

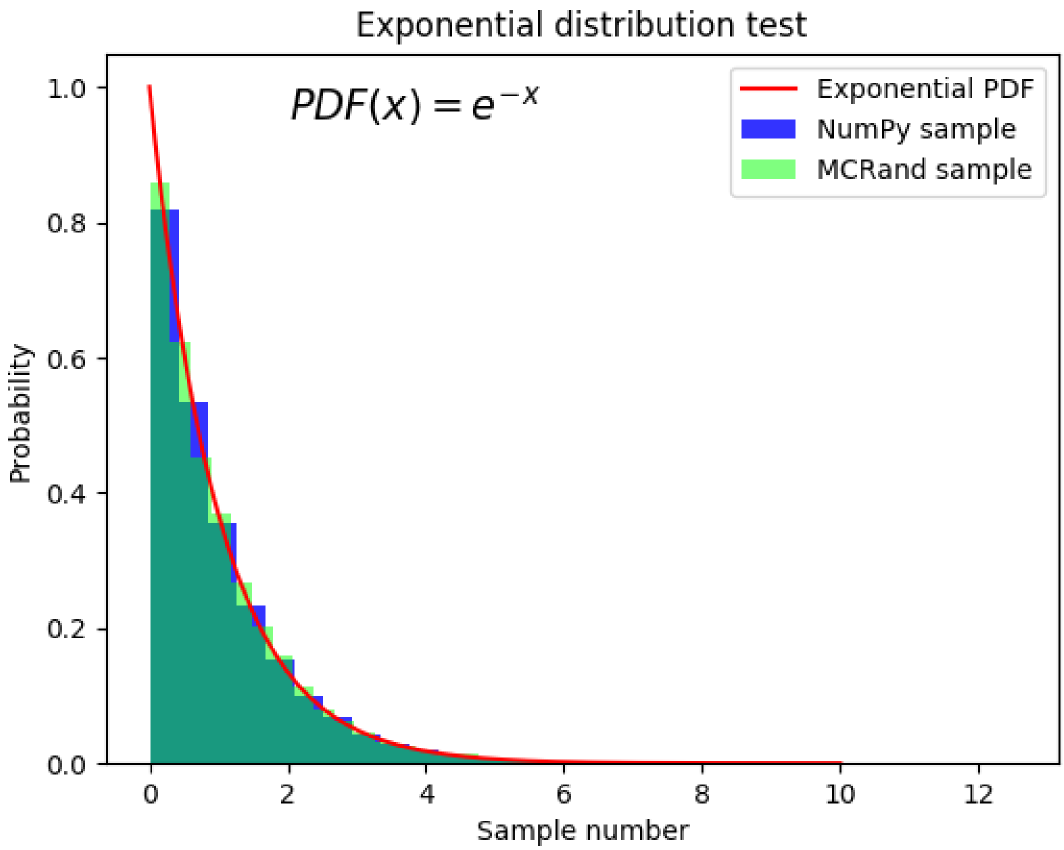


Cauchy distribution with Numpy and MCRand

From now on, we'll just write some code along with the output figures.

2.1.3 Exponential distribution

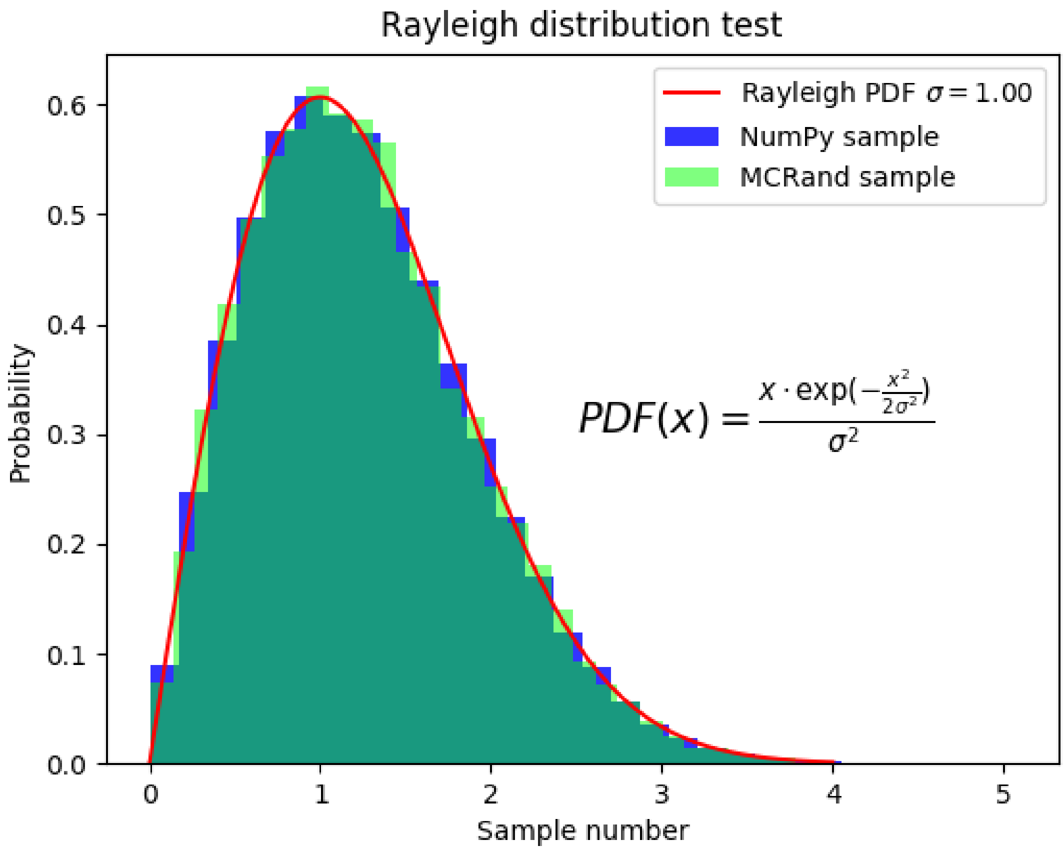
```
def exponential(x):
        return np.exp(-x)

x0 = 0
xf = 10
N = 10**5

rand = sample(exponential, x0, xf, N)

plt.hist(numpy_rand, bins=30, density=True, color=(0,0,1,0.8), label='NumPy sample')
plt.hist(rand, bins=30, density=True, color=(0,1,0,0.5), label='MCRand sample')
```



Exponential distribution with Numpy and MCRand

2.1.4 Rayleigh distribution

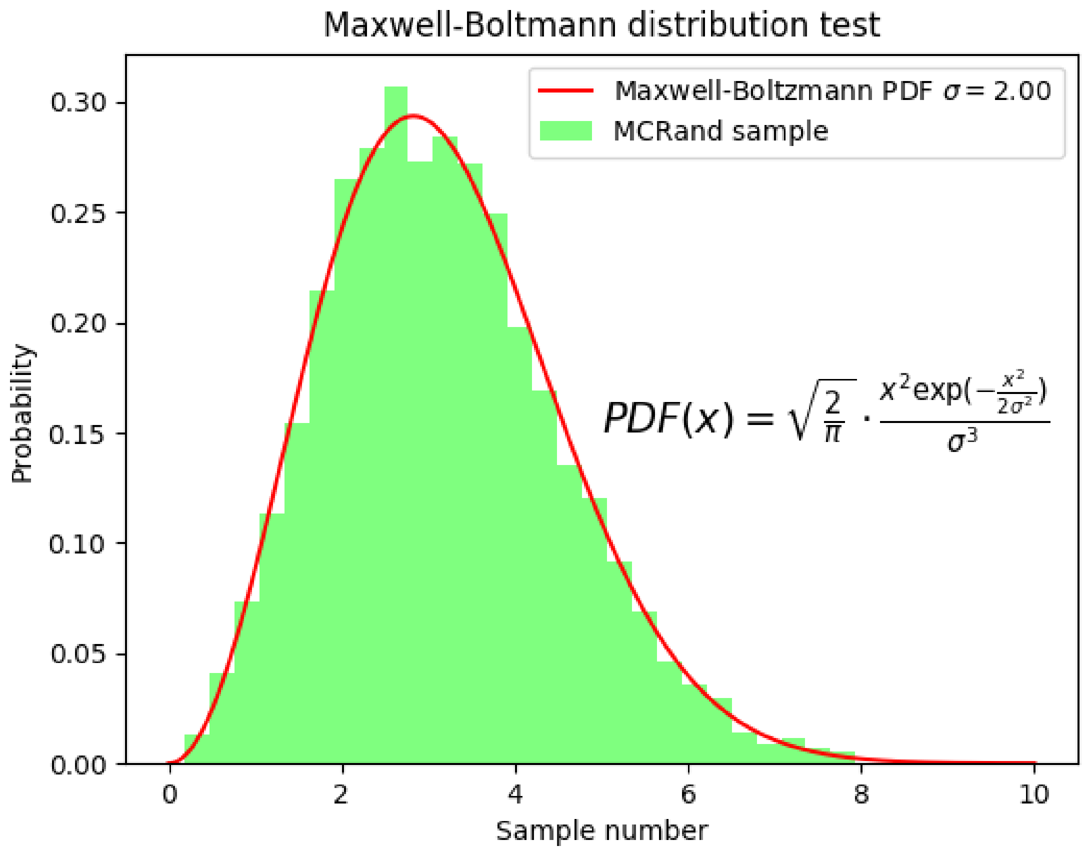
```
def rayleigh(x, sigma):
        return (x*np.exp(-(x**2)/(2*sigma**2))) / (sigma**2)

x0 = 0
xf = 4
sigma = 1
N = 10**5

rand = sample(rayleigh, x0, xf, N, sigma)

plt.hist(rand, bins=30, density=True, color=(0,1,0,0.5), label='MCRand sample')
plt.plot(x, rayleigh(x, sigma), color='r', label=r'Rayleigh PDF $\sigma=%.2f$' %
↪sigma)
```



Rayleigh distribution with Numpy and MCRand

2.1.5 Maxwell-Boltzmann distribution

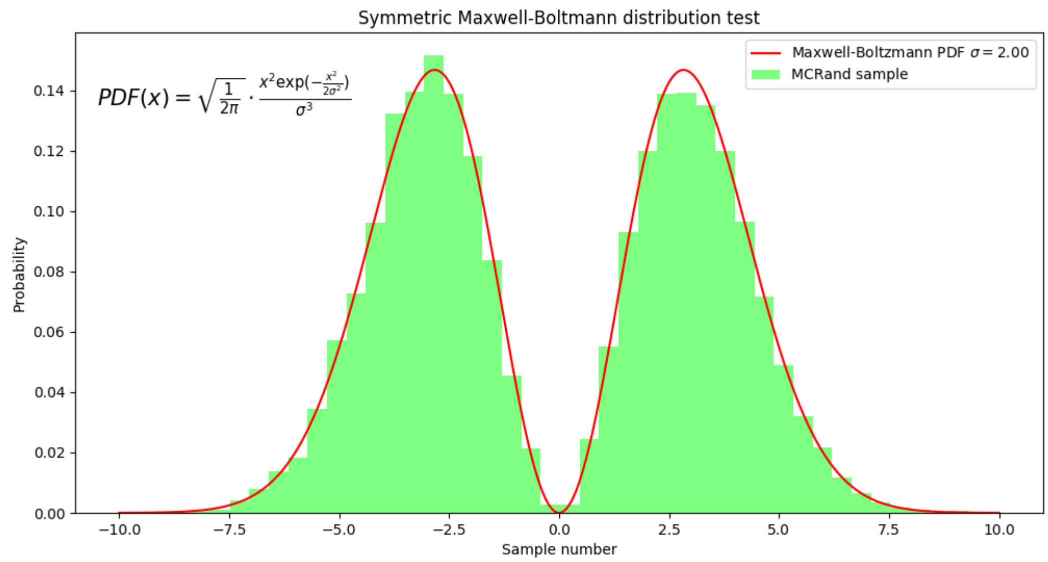
```
def maxwell_boltzmann(x, sigma):
        return (np.sqrt(2/np.pi))*(x**2*np.exp(-(x**2)/(2*sigma**2))) / (sigma**3)

x0 = 0
xf = 10
sigma = 2
N = 10**5

rand = sample(maxwell_boltzmann, x0, xf, N, sigma)

plt.hist(rand, bins=30, density=True, color=(0,1,0,0.5), label='MCRand sample')
plt.plot(x, maxwell_boltzmann(x, sigma), color='r', label=r'Maxwell-Boltzmann PDF
↪$\sigma=%.2f$' % sigma)
```



Maxwell-Boltzmann distribution with Numpy and MCRand

2.1.6 Symmetric Maxwell-Boltzmann distribution

```
def symmetric_maxwell_boltzmann(x, sigma):
        return 0.5*(np.sqrt(2/np.pi))*(x**2*np.exp(-(x**2)/(2*sigma**2))) / (sigma**3)

x0 = -10
xf = 10
sigma = 2
N = 10**5

rand = sample(symmetric_maxwell_boltzmann, x0, xf, N, sigma)

plt.hist(rand, bins=40, density=True, color=(0,1,0,0.5), label='MCRand sample')
plt.plot(x, symmetric_maxwell_boltzmann(x, sigma), color='r', label=r'Maxwell-
↪Boltzmann PDF $\sigma=%.2f$' % sigma)
```



Symmetric Maxwell-Boltzmann distribution with Numpy and MCRand

2.1.7 Modified Rayleigh distribution

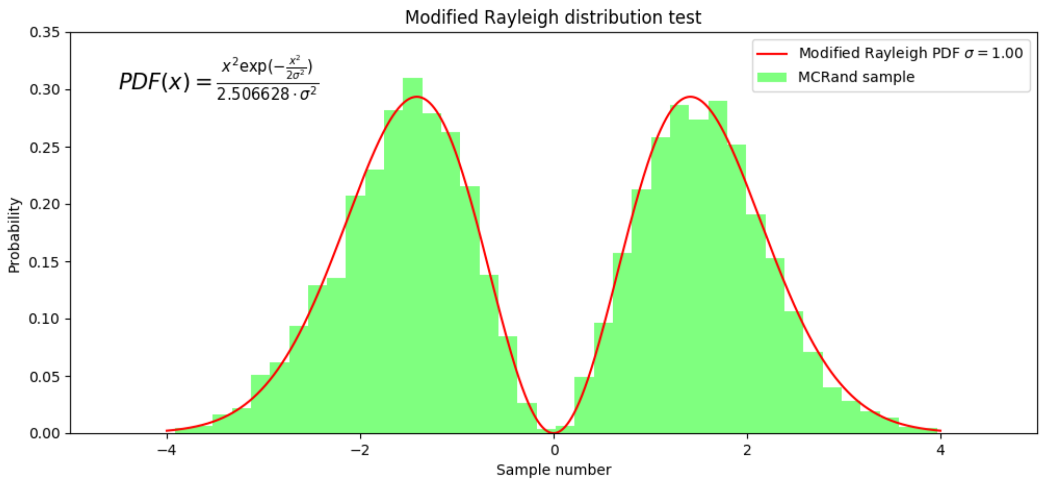
Finally we consider a invented probability distribution, given by the Rayleigh distribution multiplied by `x`. In some way we making a symmetric Rayleigh distribution. Then, this new distribution must be normalized, so the following equation must be acomplished:

equation

By nummeric integration it turns out that the normalization constant must be `C=1/2.506628`. Then we get the probability density function for this distribution.

Therefore, MCRand can be used to generate random numbers distributed following this distribution as follows

```
def invented(x, sigma):
        return (x**2*np.exp(-(x**2)/(2*sigma**2))) / (2.506628*sigma**2)

x0 = -4
xf = 4
sigma = 1
N = 10**5

rand = sample(invented, x0, xf, N, sigma)

plt.hist(rand, bins=40, density=True, color=(0,1,0,0.5), label='MCRand sample')
plt.plot(x, invented(x, sigma), color='r', label=r'Modified Rayleigh PDF $\sigma=%.2f$
↪' % sigma)
```



Modified Rayleigh distribution with Numpy and MCRand

2.2 Multidimensional Integration

To use the MCRand library to perform multidimensional integrals we first need to import the Integrate module. This step can be done in the following way

```
from mcrand import uniform_integration
```

Then, we must define the function to integrate in an NumPy ndarray supported way, so it must be defined generally. For instance let's imagine we want so solve the following integral:

equation

Then we should define the function as

```
def func(x):
        return np.sum(np.power(x, 2))
```

so each element of the x array will represent a variable.

Finally, to get the result with its error we can run the following code

```
x0 = [0, 0]
xf = [2, 3]
N = 10**6

result = uniform_integration(func, x0, xf, N)

print(result)
```

The result is given in the following format

```
(25.99767534344232, 0.02023068196284685)
```

CHAPTER 3

API Reference

`mcrand.`**`distribution`**(*pdf*, *bounds*, *max_sample=100000*, **args*)

Generator of random numbers following the given probability density function.

Parameters

pdf [func] the probability density function.

- **Input parameters:**
  - ***x*** [float] the evaluation point
  - ****args*** [tuple] extra parameters
- **Output parameters:**
  - *y* : float

bounds [tuple of floats] lower and upper limit

max_sample [int] the quantity of random numbers to return

***args** [args] extra arguments for the pdf

Returns

random_numbers [numpy.ndarray] collection of random numbers following the given pdf.

Notes

pdf is expected to be a probability density function therefore it must be positively defined in the range specified.

`mcrand.`**`sample`**(*pdf*, *x0*, *xf*, *shape*, **args*)

Generator of random numbers following the given probability density function.

Parameters

pdf [func] the probability density function

x0 [float] the lower limit

xf [float] the upper limit

shape [int or tuple of ints] the shape of the generated random numbers array

***args** [args] extra arguments for the pdf

Returns

random_numbers [numpy.ndarray] collection of random numbers following the given pdf with the specified shape.

See also:

mcrand.distribution

`mcrand.`**`uniform_integration`**(*f*, *limits*, *N*, **args*)

MonteCarlo integration of multidimensional functions.

Parameters

f [func] integration function. input parameters: * x : numpy.ndarray

the evaluation point, n-dimensional vector

- ***args** [tuple] extra parameters

output parameters: * y : float

limits [list of tuple] a list containing the lower and upper limits of integration for each dimension as tuple with two ints (low, high).

N [int] number of points used

***args** [args] extra arguments for the evaluation function

Returns

integral [float] the result of the integral

error [float] the standard deviation

CHAPTER 4

Contact

You may open an issue in the GitHub page.

CHAPTER 5

Indices and tables

- genindex
- modindex
- search

Python Module Index

m

Index

D

M

S

U