norm_pdf_unit_test

November 7, 2019

1 Unit test

Compare the output of `scipy.stats.norm.pdf` with hand-written gaussian `normpdf` to make sure the argument scaling is correct.

Notebook adapted from the scipy docs.

[1]:
```
from scipy.stats import norm
import numpy as np
import matplotlib.pyplot as plt
```

Scipy defines the probability density function (PDF) for a normal distribution as the following:

$$f(x) = \frac{\exp\left(\frac{x^2}{2}\right)}{\sqrt{2\pi}}$$

Shifting or scaling `norm.pfd` is achieved by passing the `loc` and `scale` parameters, i.e. `norm.pdf(x, loc, scale)`. Where `loc` specifies the mean and `scale` specifies the standard deviation.

[2]:
```
# print 'percent point function (ppf, inverse of `cdf`) at quantile
# corresponding to the lower tail probability q of the given random variable'

print(norm.ppf(0.01))
print(norm.ppf(0.99))
```

```
-2.3263478740408408
2.3263478740408408
```

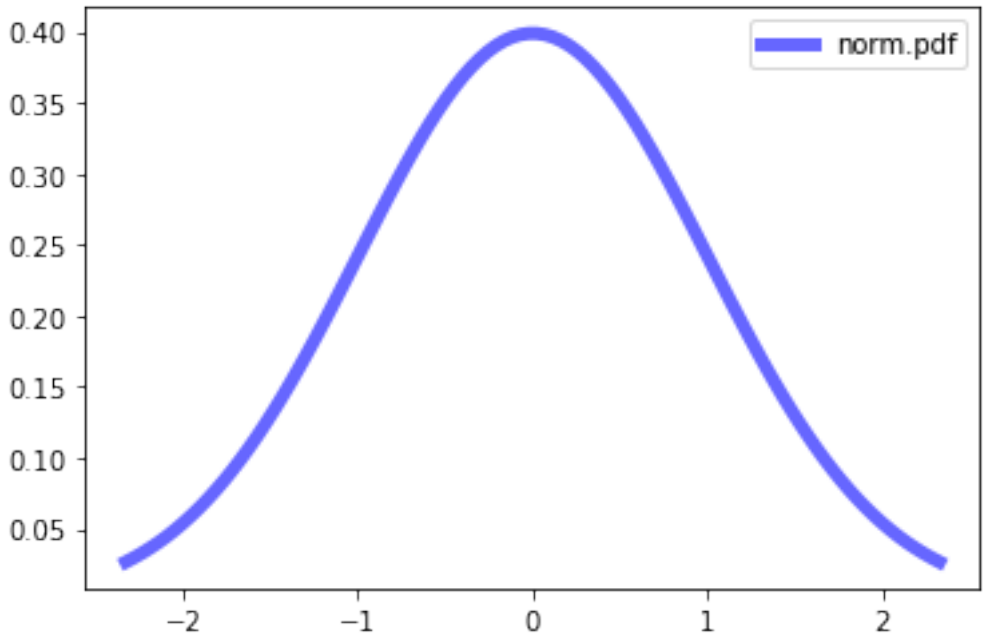
[3]:
```
x = np.linspace(norm.ppf(0.01), norm.ppf(0.99), 100)
x
```

[3]:
```
array([-2.32634787, -2.27935095, -2.23235402, -2.18535709, -2.13836017,
       -2.09136324, -2.04436631, -1.99736939, -1.95037246, -1.90337553,
       -1.85637861, -1.80938168, -1.76238475, -1.71538783, -1.6683909 ,
       -1.62139397, -1.57439705, -1.52740012, -1.48040319, -1.43340627,
       -1.38640934, -1.33941241, -1.29241549, -1.24541856, -1.19842163,
       -1.15142471, -1.10442778, -1.05743085, -1.01043393, -0.963437  ,
       -0.91644007, -0.86944314, -0.82244622, -0.77544929, -0.72845236,
```

```
-0.68145544, -0.63445851, -0.58746158, -0.54046466, -0.49346773,
-0.4464708 , -0.39947388, -0.35247695, -0.30548002, -0.2584831 ,
-0.21148617, -0.16448924, -0.11749232, -0.07049539, -0.02349846,
 0.02349846,  0.07049539,  0.11749232,  0.16448924,  0.21148617,
 0.2584831 ,  0.30548002,  0.35247695,  0.39947388,  0.4464708 ,
 0.49346773,  0.54046466,  0.58746158,  0.63445851,  0.68145544,
 0.72845236,  0.77544929,  0.82244622,  0.86944314,  0.91644007,
 0.963437  ,  1.01043393,  1.05743085,  1.10442778,  1.15142471,
 1.19842163,  1.24541856,  1.29241549,  1.33941241,  1.38640934,
 1.43340627,  1.48040319,  1.52740012,  1.57439705,  1.62139397,
 1.6683909 ,  1.71538783,  1.76238475,  1.80938168,  1.85637861,
 1.90337553,  1.95037246,  1.99736939,  2.04436631,  2.09136324,
 2.13836017,  2.18535709,  2.23235402,  2.27935095,  2.32634787])
```

Display PDF:

[4]:
```
fig, ax = plt.subplots(1, 1)
ax.plot(x, norm.pdf(x), 'b-', lw=5, alpha=0.6, label='norm.pdf')
ax.legend(loc='best');
```



[5]:
```
# generate array of random variates of a given `size`

r = norm.rvs(size=1000)
r
```

```
[5]: array([-3.40299679e-01,  1.29142838e+00,  8.21096895e-01, -1.76362028e+00,
            -2.40727945e+00, -9.12172553e-01,  1.03332417e+00,  6.70661992e-02,
             1.13250428e+00,  1.08378714e+00,  2.13821734e+00,  2.42442153e+00,
            -1.77101514e-01, -7.94038471e-01, -1.50907891e+00,  2.20599982e+00,
             2.23591507e+00,  4.30135843e-01,  1.32388113e+00, -6.40991768e-01,
             1.10259057e+00, -3.41276539e-01,  5.80262481e-01, -3.76552470e-01,
             1.36570051e+00, -7.60130712e-01,  1.81909781e+00,  3.18610207e-01,
            -8.17202285e-01, -6.35782696e-03,  8.99051893e-01, -1.94613144e-01,
            -7.39799906e-01,  2.13633138e-01, -2.76802965e-01, -1.45467915e+00,
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```

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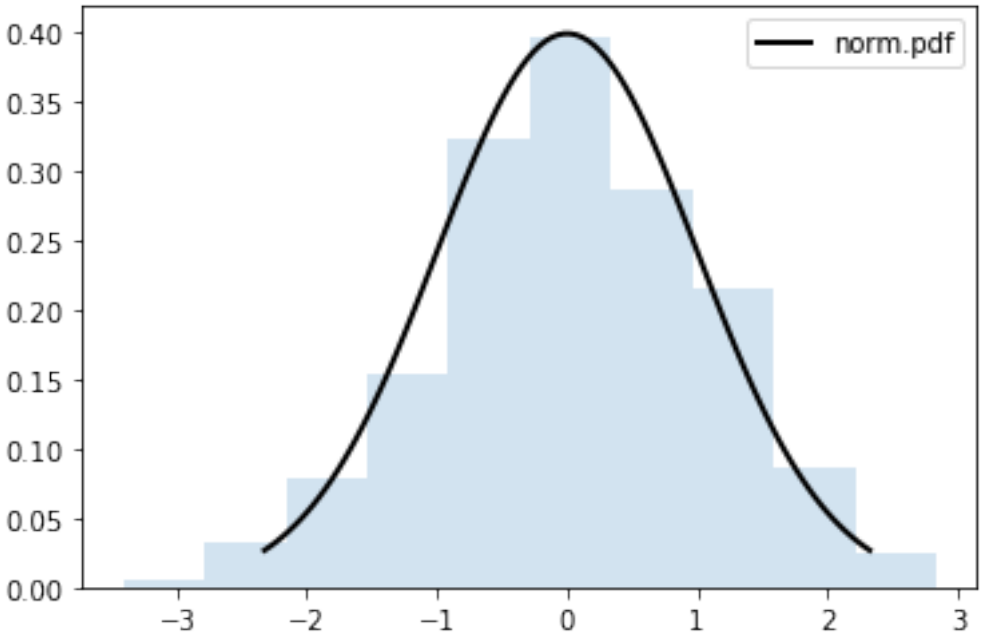
 6.08125875e-02, -3.69147990e-01, -1.68662821e-01,  1.89352695e-01])
```

[6]:
```
fig, ax = plt.subplots(1, 1)
ax.plot(x, norm.pdf(x), 'k-', lw=2, label='norm.pdf')
ax.hist(r, density=True, histtype='stepfilled', alpha=0.2)
ax.legend(loc='best');
```



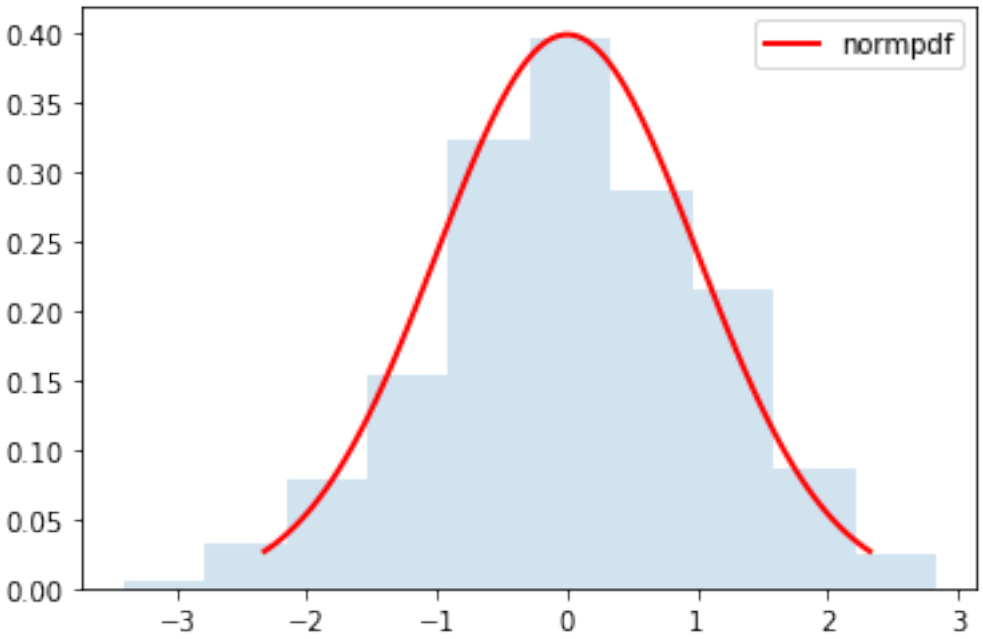
1.1 Define hand-written function for PDF of a normal distribution

$$f(x) = \frac{\exp\left(\frac{\frac{x-\mu}{\sigma}}{2}\right)^2}{\sqrt{2\pi}}$$

Where μ is the mean and σ is the standard deviation.

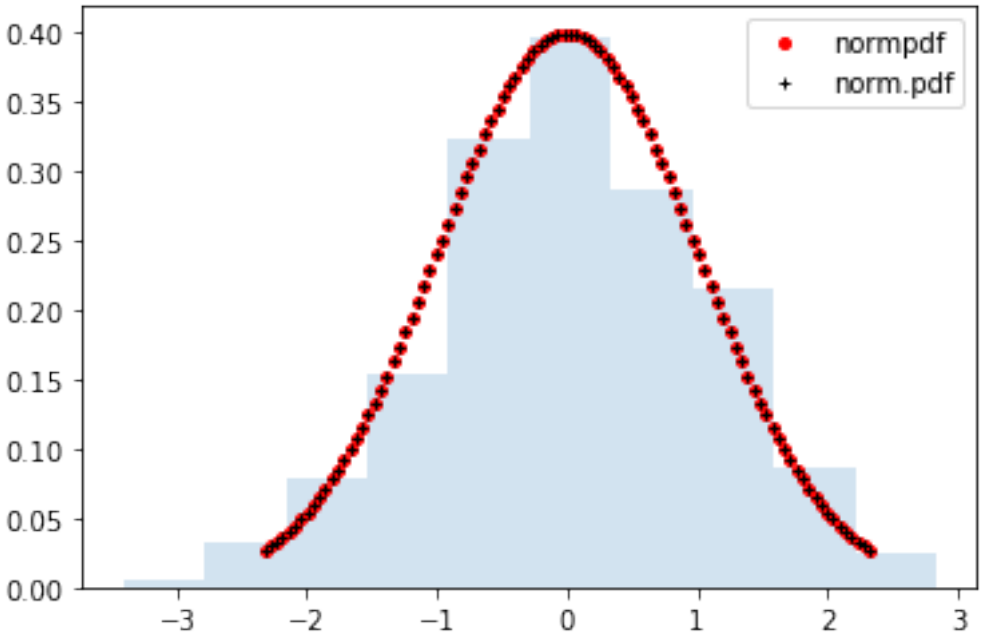
[7]:
```
def normpdf(x, mu=0, sigma=1.):
    """Return the normal pdf evaluated at `x`."""
    assert sigma > 0
    u = (x-mu)/sigma
    y = 1/(np.sqrt(2*np.pi)*sigma)*np.exp(-u*u/2)
    return y
```

[8]:
```
fig, ax = plt.subplots(1, 1)
ax.plot(x, normpdf(x), 'r-', lw=2, label='normpdf')
ax.hist(r, density=True, histtype='stepfilled', alpha=0.2)
ax.legend(loc='best');
```



Overlay plots:

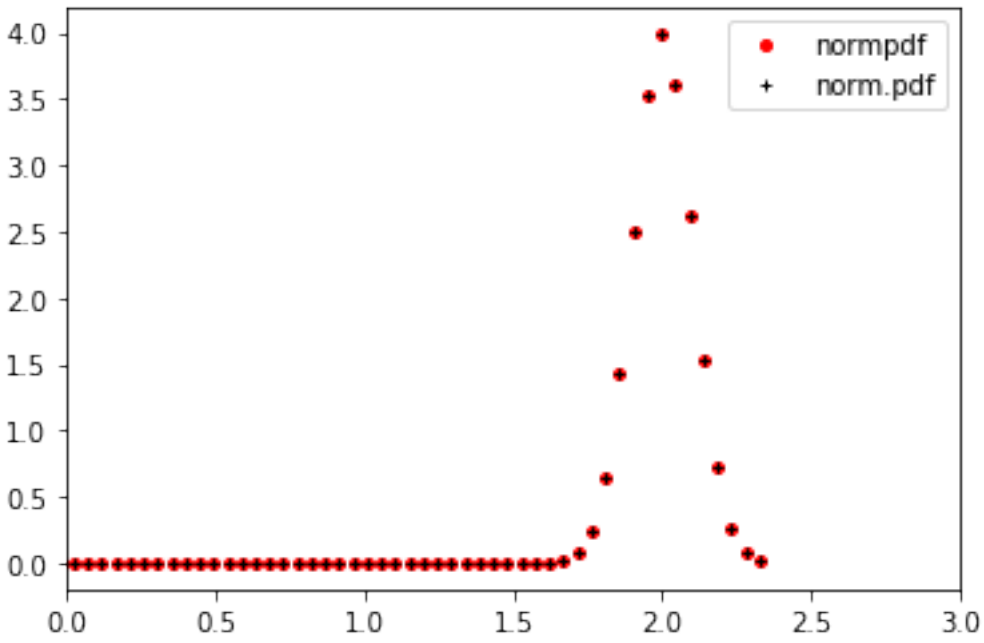
[9]:
```
fig, ax = plt.subplots(1, 1)
ax.plot(x, normpdf(x), 'ro', ms=4, label='normpdf')
ax.plot(x, norm.pdf(x), 'k+', ms=4, label='norm.pdf')
ax.hist(r, density=True, histtype='stepfilled', alpha=0.2)
ax.legend(loc='best');
```



1.2 Test scaling of `norm.pdf`

[10]:
```
sigma = 0.1
mu = 2

fig, ax = plt.subplots(1, 1)
ax.plot(x, normpdf(x, mu=mu, sigma=sigma), 'ro', ms=4, label='normpdf')
ax.plot(x, norm.pdf(x, loc=mu, scale=sigma), 'k+', ms=4, label='norm.pdf')
ax.set_xlim(0, 3)
ax.legend(loc='best');
```

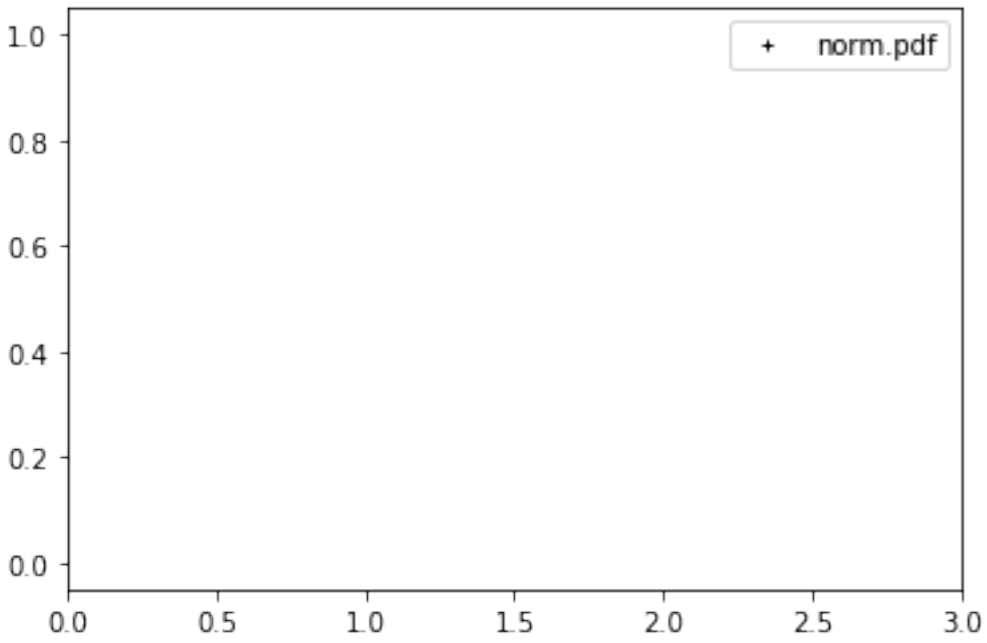


Note that there are no explicit requirements on the parameter `scale` in `norm.pdf`:

[11]:
```
sigma = 0
mu = 2

fig, ax = plt.subplots(1, 1)
#ax.plot(x, normpdf(x, mu=mu, sigma=sigma), 'ro', ms=4, label='normpdf')
ax.plot(x, norm.pdf(x, loc=mu, scale=sigma), 'k+', ms=4, label='norm.pdf')
ax.set_xlim(0, 3)
ax.legend(loc='best');
```

```
/Users/maya/anaconda3/envs/py37-fb/lib/python3.7/site-
packages/scipy/stats/_distn_infrastructure.py:1720: RuntimeWarning: divide by
zero encountered in true_divide
  x = np.asarray((x - loc)/scale, dtype=dtyp)
```



while `normpdf` will give return an `AssertionError`:

[12]:
```
sigma = 0
mu = 2

fig, ax = plt.subplots(1, 1)
ax.plot(x, normpdf(x, mu=mu, sigma=sigma), 'ro', ms=4, label='normpdf')
ax.plot(x, norm.pdf(x, loc=mu, scale=sigma), 'k+', ms=4, label='norm.pdf')
ax.set_xlim(0, 3)
ax.legend(loc='best');
```

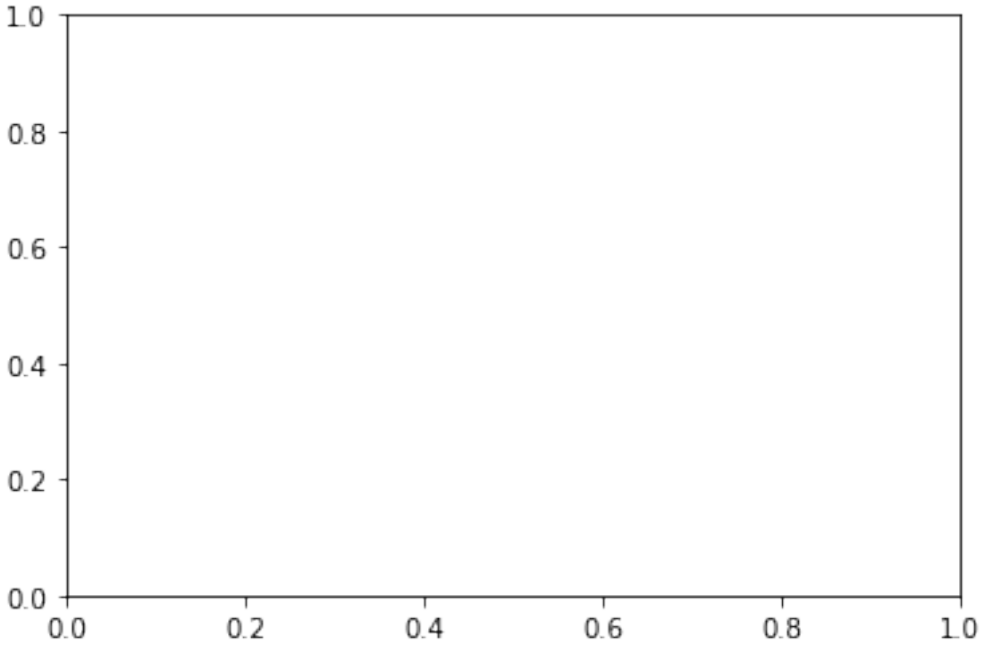
```
␣
↪---------------------------------------------------------------------------

AssertionError                            Traceback (most recent call␣
↪last)

<ipython-input-12-e153823a3b9a> in <module>
      3
      4 fig, ax = plt.subplots(1, 1)
----> 5 ax.plot(x, normpdf(x, mu=mu, sigma=sigma), 'ro', ms=4,␣
↪label='normpdf')
      6 ax.plot(x, norm.pdf(x, loc=mu, scale=sigma), 'k+', ms=4, label='norm.
↪pdf')
      7 ax.set_xlim(0, 3)
```

```
    <ipython-input-7-2b1de40437aa> in normpdf(x, mu, sigma)
      1 def normpdf(x, mu=0, sigma=1.):
      2     """Return the normal pdf evaluated at `x`."""
----> 3     assert sigma > 0
      4     u = (x-mu)/sigma
      5     y = 1/(np.sqrt(2*np.pi)*sigma)*np.exp(-u*u/2)


    AssertionError:
```



[ ]: