06ex_Visualization

March 14, 2020

1. **Kernel Density Estimate**
Produce a KDE for a given distribution (by hand, not using seaborn!):

- Fill a numpy array, x, of len(N) (with N=O(100)) with a variable normally distributed, with a given mean a standard deviation
- Fill an histogram in pyplot taking properly care about the aesthetic
  - use a meaningful number of bins
  - set a proper y axis label
  - set proper value of y axis major ticks labels (e.g. you want to display only integer labels)
  - display the histograms as data points with errors (the error being the poisson uncertainty)
- for every element of x, create a gaussian with the mean corresponding the element value and std as a parameter that can be tuned. The std default value should be:

$$1.06 * x.std() * x.size^{-\frac{1}{5.}}$$

  you can use the scipy function `stats.norm()` for that.
- In a separate plot (to be placed beside the original histogram), plot all the gaussian functions so obtained
- Sum (with np.sum()) all the gaussian functions and normalize the result such that the integral matches the integral of the original histogram. For that you could use the `scipy.integrate.trapz()` method

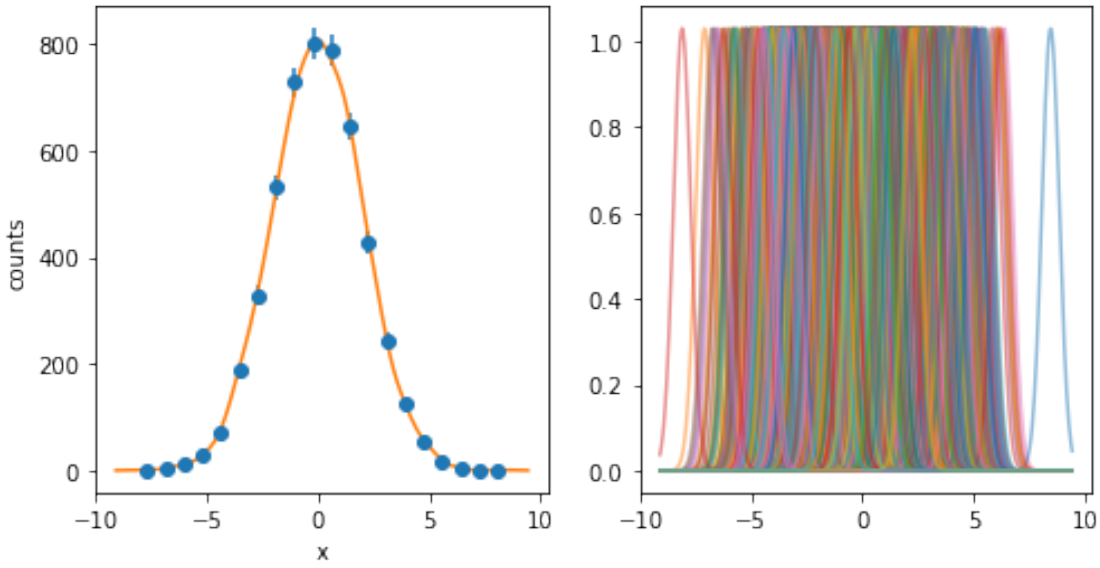
```
In [1]: import numpy as np
        from IPython.display import Image
        import matplotlib.pyplot as plt
        import scipy
        from scipy.stats import norm
        %matplotlib inline
```

```
In [2]: x = np.random.normal(0,2,5000)
        counts,bin_edges = np.histogram(x,20)
        bin_centres = (bin_edges[:-1] + bin_edges[1:])/2.
        err = np.random.rand(bin_centres.size)*100

        fig, (fig1, fig2)= plt.subplots(nrows=1, ncols=2, figsize=(8, 4))
        fig1.errorbar(bin_centres, counts, yerr=np.sqrt(counts), fmt='o', label= ('x', 'counts
```

```
        fig1.set_xlabel("x")
        fig1.set_ylabel("counts")
        std=1.06*x.std()*x.size**(-1/5)
        xr=np.arange(min(x)-1, max(x)+1, 0.05)
        print(min(x), max(x))

        g=[norm.pdf(xr,a, std) for a in x]
        #print (g)
        for f in g:
            fig2.plot(xr, f, label= ('x', 'counts'), alpha=0.5)

        s=np.sum(g, axis=0)
        width=bin_centres[1]-bin_centres[0]
        s*=np.sum(width*counts)/scipy.integrate.trapz(s, xr)
        fig1.plot(xr,s)
```

```
-8.107449820858108 8.47629331499556
```

```
Out[2]: [<matplotlib.lines.Line2D at 0x7efbae641da0>]
```



2. **Color-coded scatter plot**
Produce a scatter plot out of a dataset with two categories

- Write a function that generate a 2D datasets of 2 categories. Each category should distribute as a 2D gaussian with a given mean and std (clearly it is better to have different values means..)
- Display the dataset in a scatter plot marking the two categories with different marker colors.

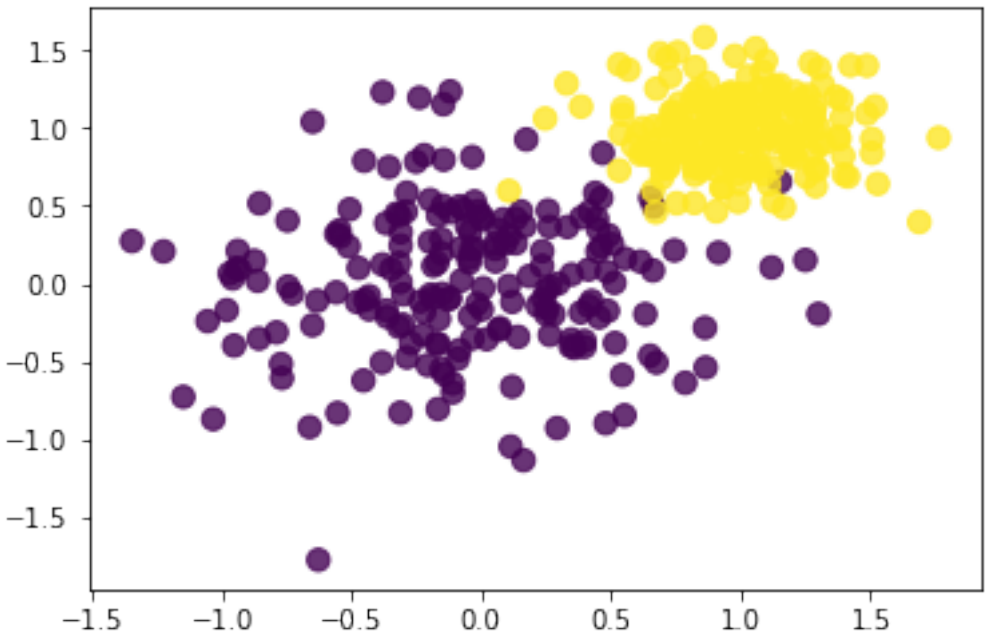
An example is given below

You can try to make the procedure more general by allowing a given number $n \geq 2$ of categories

```
In [3]: ! wget https://www.dropbox.com/s/u4y3k4kk5tc7j46/two_categories_scatter_plot.png
        from IPython.display import Image
        Image('two_categories_scatter_plot.png')
```

```
--2020-03-14 14:24:21--  https://www.dropbox.com/s/u4y3k4kk5tc7j46/two_categories_scatter_plot
Resolving www.dropbox.com (www.dropbox.com)... 162.125.69.1, 2620:100:6025:1::a27d:4501
Connecting to www.dropbox.com (www.dropbox.com)|162.125.69.1|:443... connected.
HTTP request sent, awaiting response... 301 Moved Permanently
Location: /s/raw/u4y3k4kk5tc7j46/two_categories_scatter_plot.png [following]
--2020-03-14 14:24:24--  https://www.dropbox.com/s/raw/u4y3k4kk5tc7j46/two_categories_scatter_
Reusing existing connection to www.dropbox.com:443.
HTTP request sent, awaiting response... 302 Found
Location: https://ucef958a5858ed8fab06e87f34e9.dl.dropboxusercontent.com/cd/0/inline/Az6OtY0DS
--2020-03-14 14:24:25--  https://ucef958a5858ed8fab06e87f34e9.dl.dropboxusercontent.com/cd/0/i
Resolving ucef958a5858ed8fab06e87f34e9.dl.dropboxusercontent.com (ucef958a5858ed8fab06e87f34e9
Connecting to ucef958a5858ed8fab06e87f34e9.dl.dropboxusercontent.com (ucef958a5858ed8fab06e87f
HTTP request sent, awaiting response... 200 OK
Length: 43828 (43K) [image/png]
Saving to: two_categories_scatter_plot.png.1

two_categories_scat 100%[===================>]  42,80K   129KB/s    in 0,3s

2020-03-14 14:24:27 (129 KB/s) - two_categories_scatter_plot.png.1 saved [43828/43828]
```

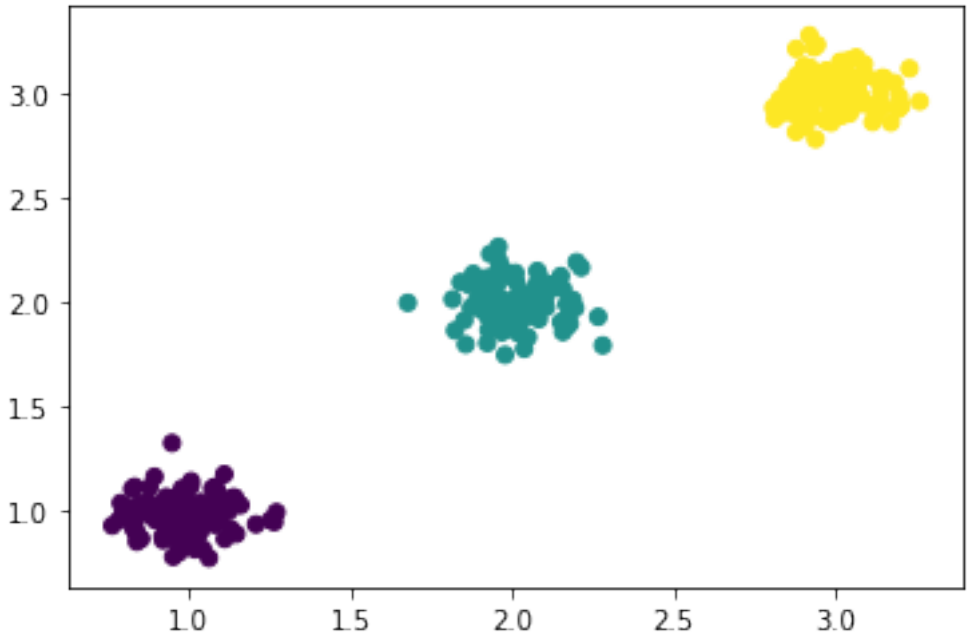
```
Out[3]:
```



In [4]:
```
import numpy as np
import matplotlib.pyplot as plt

def make_dataset(values, n):
    a=np.zeros((5,2))
    np.random.seed(1234429)
    for i in range(len(values)):
        mean=values[i][0]
        width=values[i][1]
        b=width*np.random.randn(n,2)+np.array(mean).reshape(1,2)
        b=np.c_[b, np.ones(n)*i]
        if i==0:
            a=b
        else:
            a=np.append(a,b, axis=0)
    return a
```

In [5]:
```
val=[([1,1],0.1), ([2,2],0.1), ([3,3],0.1)] #centers and width

data=make_dataset(val, 100)
#print(data)

plt.scatter(data[:,0], data[:,1],c=data[:,2] )
```

Out[5]: <matplotlib.collections.PathCollection at 0x7efbad8ada20>



3. **Profile plot**

Produce a profile plot from a scatter plot. * Download the following dataset and load it as a pandas dataframe:

```
wget https://www.dropbox.com/s/hgnvyj9abatk8g6/residuals_261.npy
```

Note that you should you the `np.load()` function to load the file as a numpy array and then pass it to the `pd.DataFrame()` constructor. * Inspect the dataset, you'll find two variables (features) * Clean the sample by selecting the entries (rows) with the variable "residual" in absolute value smaller than 2 * perform a linear regression of "residuals" versus "distances" using `scipy.stats.linregress()` * plot a seaborn jointplot of "residuals" versus "distances", having seaborn performing a linear regression. The result of the regression should be displayed on the plot * Fill 3 numpy arrays * x, serving as an array of bin centers for the "distance" variable. It should range from 0 to 20 with reasonable number of steps (bins) * y, the mean values of the "residuals", estimated in slices (bins) of "distance" * erry, the standard deviation of the of the "residuals", estimated in slices (bins) of "distance" * Plot the profile plot on top of the scatter plot

```
In [6]: ! wget https://www.dropbox.com/s/hgnvyj9abatk8g6/residuals_261.npy

--2020-03-14 14:24:28--  https://www.dropbox.com/s/hgnvyj9abatk8g6/residuals_261.npy
Resolving www.dropbox.com (www.dropbox.com)... 162.125.69.1, 2620:100:6025:1::a27d:4501
Connecting to www.dropbox.com (www.dropbox.com)|162.125.69.1|:443... connected.
HTTP request sent, awaiting response... 301 Moved Permanently
Location: /s/raw/hgnvyj9abatk8g6/residuals_261.npy [following]
--2020-03-14 14:24:29--  https://www.dropbox.com/s/raw/hgnvyj9abatk8g6/residuals_261.npy
Reusing existing connection to www.dropbox.com:443.
HTTP request sent, awaiting response... 302 Found
```

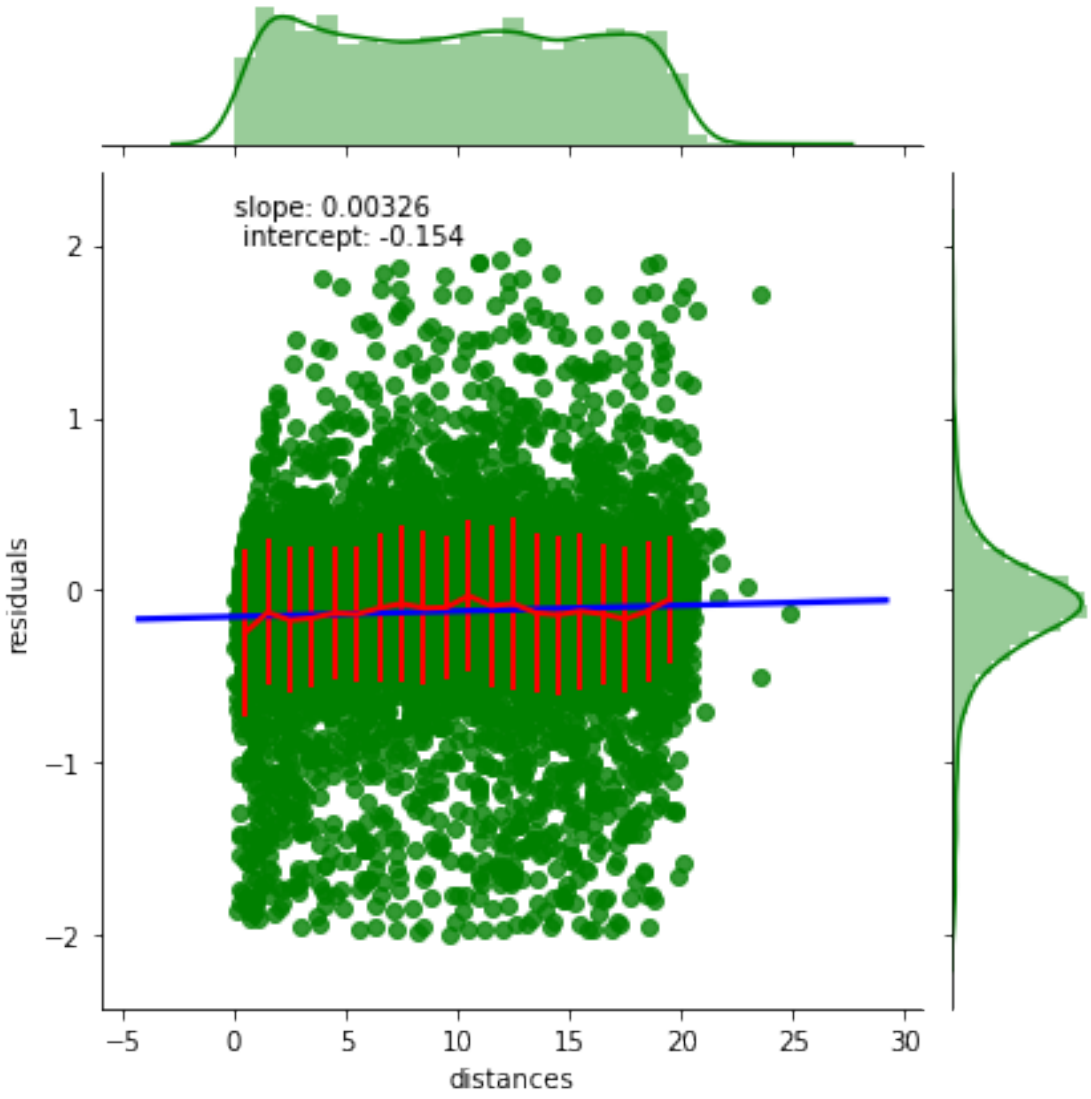
```
Location: https://uc31b85839e689533cea83514290.dl.dropboxusercontent.com/cd/0/inline/Az4jLk4Wc
--2020-03-14 14:24:29--  https://uc31b85839e689533cea83514290.dl.dropboxusercontent.com/cd/0/in
Resolving uc31b85839e689533cea83514290.dl.dropboxusercontent.com (uc31b85839e689533cea83514290
Connecting to uc31b85839e689533cea83514290.dl.dropboxusercontent.com (uc31b85839e689533cea8351
HTTP request sent, awaiting response... 302 FOUND
Location: /cd/0/inline2/Az7z1wa4RdkP_w1qGsjTJZw6hFv-q9qnbz75FylmEXRuQtmCwPLbTWpGRBotE6SRI3Cxc-5
--2020-03-14 14:24:31--  https://uc31b85839e689533cea83514290.dl.dropboxusercontent.com/cd/0/in
Reusing existing connection to uc31b85839e689533cea83514290.dl.dropboxusercontent.com:443.
HTTP request sent, awaiting response... 200 OK
Length: 252081 (246K) [application/octet-stream]
Saving to: residuals_261.npy.1

residuals_261.npy.1 100%[===================>] 246,17K   133KB/s    in 1,9s

2020-03-14 14:24:33 (133 KB/s) - residuals_261.npy.1 saved [252081/252081]
```

In [7]:
```python
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import math
import scipy as sp

data=np.load("residuals_261.npy", allow_pickle=True)
data=pd.DataFrame(data.item())
data=data[abs(data["residuals"])<2]

slope, intercept, rvalue, pvalue, stderr = scipy.stats.linregress (data["distances"], d
#print(data)
print("slope: ", slope)
print("intercept: ", intercept)

delta=1.
x=np.arange(0,20, delta)+delta/2
tempy=[]
tempz=[]
for center in x:
    b=data[data["distances"]>center-delta/2]
    b=b[b["distances"]<center+delta/2]
    res=np.array(b["residuals"])
    tempy.append(np.mean(res))
    tempz.append(np.std(res))

y=np.array(tempy)
z=np.array(tempz)

import seaborn as sb
```

```
        sb.jointplot(x="distances", y="residuals", data=data, kind="reg", color="green", joint
        plt.text(0,2, "slope: "+str(slope.round(5))+"\n intercept: "+str(intercept.round(3)))
        plt.errorbar(x,y,yerr=z, label="mean", c="red", linewidth=2)
```

```
slope:  0.0032597701220305835
intercept:  -0.15432816763069473
```

Out[7]: <ErrorbarContainer object of 3 artists>



In [ ]: