021_Folien

November 23, 2018

```
In [5]: from matplotlib import pyplot as plt
        import numpy as np
        %matplotlib inline
```

1 Beschreibende Statistik

1.1 Übersicht

LagemaSS

Streuung

Graphiken

Mehrdimensionale Daten

- Diskrete Verteilung
- Kontinuierliche Verteilung

Abhängigkeit

1.2 Bivariate Stichproben

Beispiele:

- zwei Würfel
- Strom und Spannung
- Luftdruck und Höhe über Meer
- Regentropfen auf Blatt Papier (Koordinaten x und y)

2 Diskrete Verteilung

2.0.1 Kontingenztafel der *absoluten* Häufigkeiten

```
In [6]: print('===    two coins    ===')
        results = [[0, 1], [1, 1], [1, 1], [0, 0], [1, 0], [1, 1], [1, 1], [0, 1],
                   [1, 1], [1, 0], [0, 1], [0, 0], [0, 1], [1, 0], [1, 0], [0, 0],
                   [0, 1], [0, 0], [1, 1], [0, 0] ]
        print('#1 \ #2 | head | tail |')
        print('-----------------------')                            # calculate numbers
        print('head    |{:5d} |{:5d} |'.format(results.count([0, 0]), results.count([0, 1])))
        print('tail    |{:5d} |{:5d} |'.format(results.count([1, 0]), results.count([1, 1])))
```

```
===    two coins    ===
#1 \ #2 | head | tail |
-----------------------
head    |    5 |    5 |
tail    |    4 |    6 |
```

2.0.2 ... mit *Randverteilung*

In [7]:
```python
'''calculate absolute frequencies (Python list)'''
n11 = results.count([0, 0])
n12 = results.count([0, 1])
n21 = results.count([1, 0])
n22 = results.count([1, 1])
print('#1 \ #2| head | tail ||  sum  ')
print('------------------------------')
print('head   |{:5d} |{:5d} ||{:5d} '.format(  n11,     n12,    n11+n12))
print('tail   |{:5d} |{:5d} ||{:5d} '.format(  n21,     n22,    n21+n22))
print('==============================')
print('sum    |{:5d} |{:5d} ||{:5d} '.format(n11+n21, n12+n22, n11+n12+n21+n22))
```

```
#1 \ #2| head | tail ||  sum
------------------------------
head   |    5 |    5 ||   10
tail   |    4 |    6 ||   10
==============================
sum    |    9 |   11 ||   20
```

In [8]:
```python
'''calculate absolute frequencies (numpy ndarray)'''
npres = np.array(results)                         # convert data to ndarray
n11 = (npres==[0, 0]).all(axis=1).sum() # comparing (2val)-array => boolean array
n12 = (npres==[0, 1]).all(axis=1).sum() # ... only if both are True ("all")
n21 = (npres==[1, 0]).all(axis=1).sum() # ... then count as "1" (else False="0")
n22 = (npres==[1, 1]).all(axis=1).sum() # ... summing up these gives total number
print('#1 \ #2| head | tail ||  sum  ')
print('------------------------------')
print('head   |{:5d} |{:5d} ||{:5d} '.format(  n11,     n12,    n11+n12))
print('tail   |{:5d} |{:5d} ||{:5d} '.format(  n21,     n22,    n21+n22))
print('==============================')
print('sum    |{:5d} |{:5d} ||{:5d} '.format(n11+n21, n12+n22, n11+n12+n21+n22))
```

```
#1 \ #2| head | tail ||  sum
------------------------------
head   |    5 |    5 ||   10
tail   |    4 |    6 ||   10
==============================
sum    |    9 |   11 ||   20
```

2.0.3 *relative* Häufigkeiten

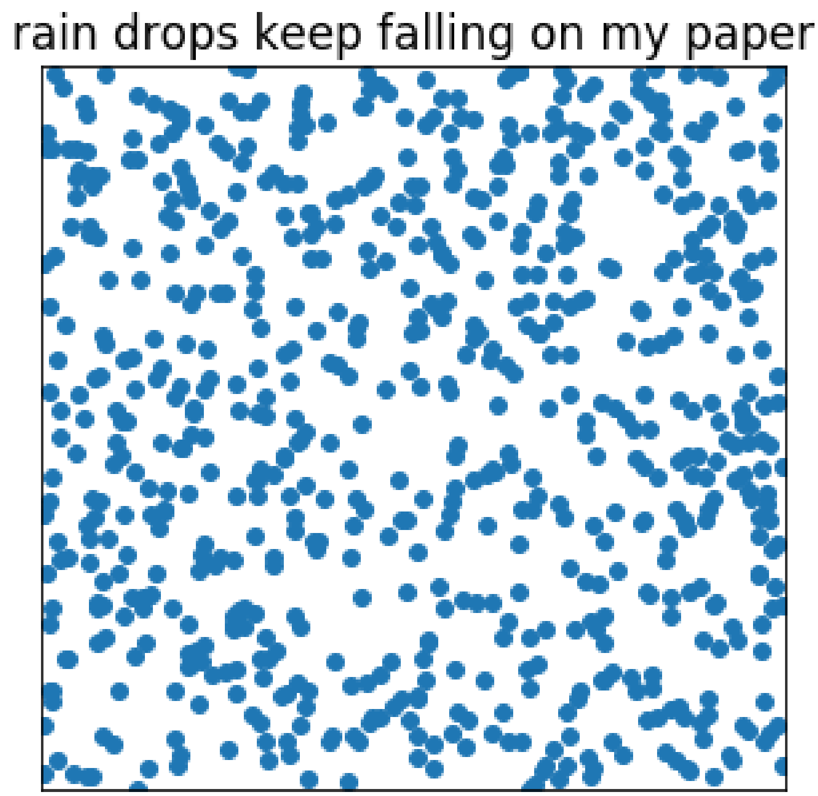
$$f_{ij} = \frac{h_{ij}}{n} \qquad f \in [0, 1]$$

```
In [9]: '''calculate relative frequencies (numpy ndarray to list)'''
        nprel = np.array(results)     # place holder for calculating relative frequency
        n = nprel.shape[0]            # number of value(pairs): 1st dimension of shape
        f11 = nprel.tolist().count([0, 0])/n      # since a list again,
        f12 = nprel.tolist().count([0, 1])/n      # ... we can count
        f21 = nprel.tolist().count([1, 0])/n      # ... different elements
        f22 = nprel.tolist().count([1, 1])/n      # ... as before
        print('#1 \ #2| head | tail ||  sum  ')
        print('------------------------------')
        print('head   |{:5.2f} |{:5.2f} ||{:5.2f} '.format(  f11,     f12,   f11+f12))
        print('tail   |{:5.2f} |{:5.2f} ||{:5.2f} '.format(  f21,     f22,   f21+f22))
        print('==============================')
        print('sum    |{:5.2f} |{:5.2f} ||{:5.2f} '.format(f11+f21, f12+f22, f11+f12+f21+f22))
```

```
#1 \ #2| head | tail ||  sum
------------------------------
head   | 0.25 | 0.25 || 0.50
tail   | 0.20 | 0.30 || 0.50
==============================
sum    | 0.45 | 0.55 || 1.00
```

3 Kontinuierliche Verteilung

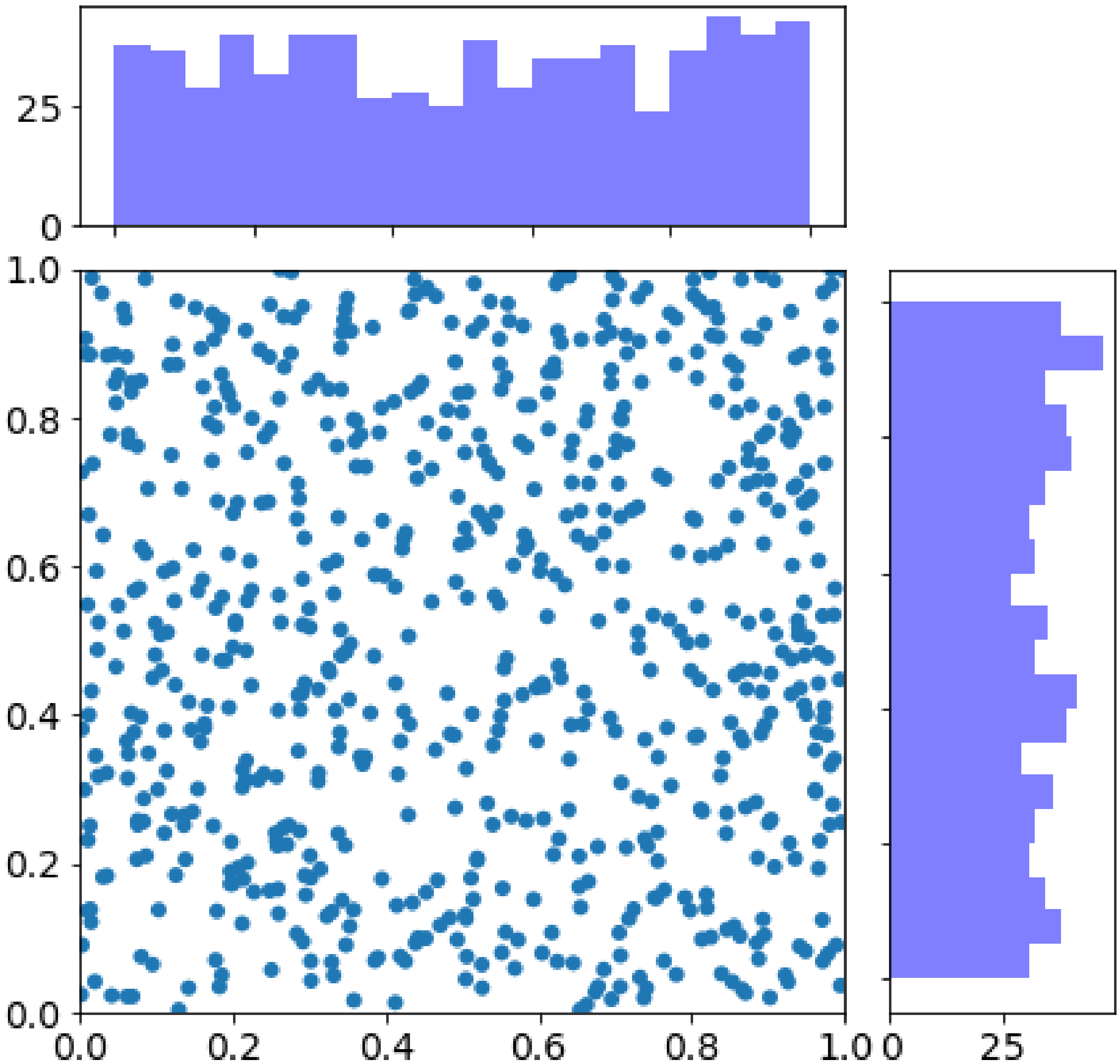
```
In [8]: '''Two dimensional random variable: raindrops on a paper'''
        f = plt.figure(figsize=(5, 5))            # square
        np.random.seed(987654)                    # initialize random generator to same
        rain = np.random.random((2, 700))         # draw 2x700  [0...1] random numbers
        plt.scatter(rain[0], rain[1])             # let it rain
        plt.axis([0, 1, 0, 1])                    # (restrict frame)
        plt.title('rain drops keep falling on my paper') # (headline)
        ax = plt.gca()                            # (get instance of axes drawn)
        ax.axes.get_xaxis().set_visible(False)    # (no tickmarks on x)
        ax.axes.get_yaxis().set_visible(False); # (            and y axis)
```



4 Streudiagramm mit Randverteilung

der einzelnen Komponenten (Dimensionen)

In [10]:
```
'''three sub-graph-axis-sets: axmx, axmy and axxy in one figure'''
fig = plt.figure(figsize=(7, 7))
bins = np.linspace(0.0, 1.0, 21)                      # 20 bins from 0 to 1
# define a 4x4 grid and distribute the virtual squares:
# upper marginal 3x1, until 3rd column
axmx = plt.subplot2grid((4, 4), (0, 0), colspan=3)
# right marginal 1x3, start 2nd row, last col
axmy = plt.subplot2grid((4, 4), (1, 3), rowspan=3)
# main window, size 3x3, start 2nd row
axxy = plt.subplot2grid((4, 4), (1, 0), colspan=3, rowspan=3)
# x-marginal histogram
axmx.hist(rain[0], color='b', bins=bins, label='x', alpha=.5)
axmy.hist(rain[1], color='b', bins=bins, label='y', alpha=.5,
            orientation='horizontal')       # y-marginal, rotated
axxy.scatter(rain[0], rain[1], edgecolor='') # let it rain in big xy-panel
axmx.xaxis.set_ticklabels([])               # no tickmarks
axmy.yaxis.set_ticklabels([])
axxy.axis([0, 1, 0, 1]);                    # restrict area to full data range
```



5 KenngröSSen mehrdimensionaler Daten

5.1 Mittelwert

Randverteilung erlaubt Bestimmung des 2D-Mittelwerts

5.2 Varianz

Randverteilung erlaubt Bestimmung der 2D-Streuung(en)

es sollt auch in 2D

```
In [11]: print('the mean of rain-X is {:.2f}'.format(rain[0].mean()))
         print('the mean of rain-Y is {:.2f}'.format(rain[1].mean()))
```

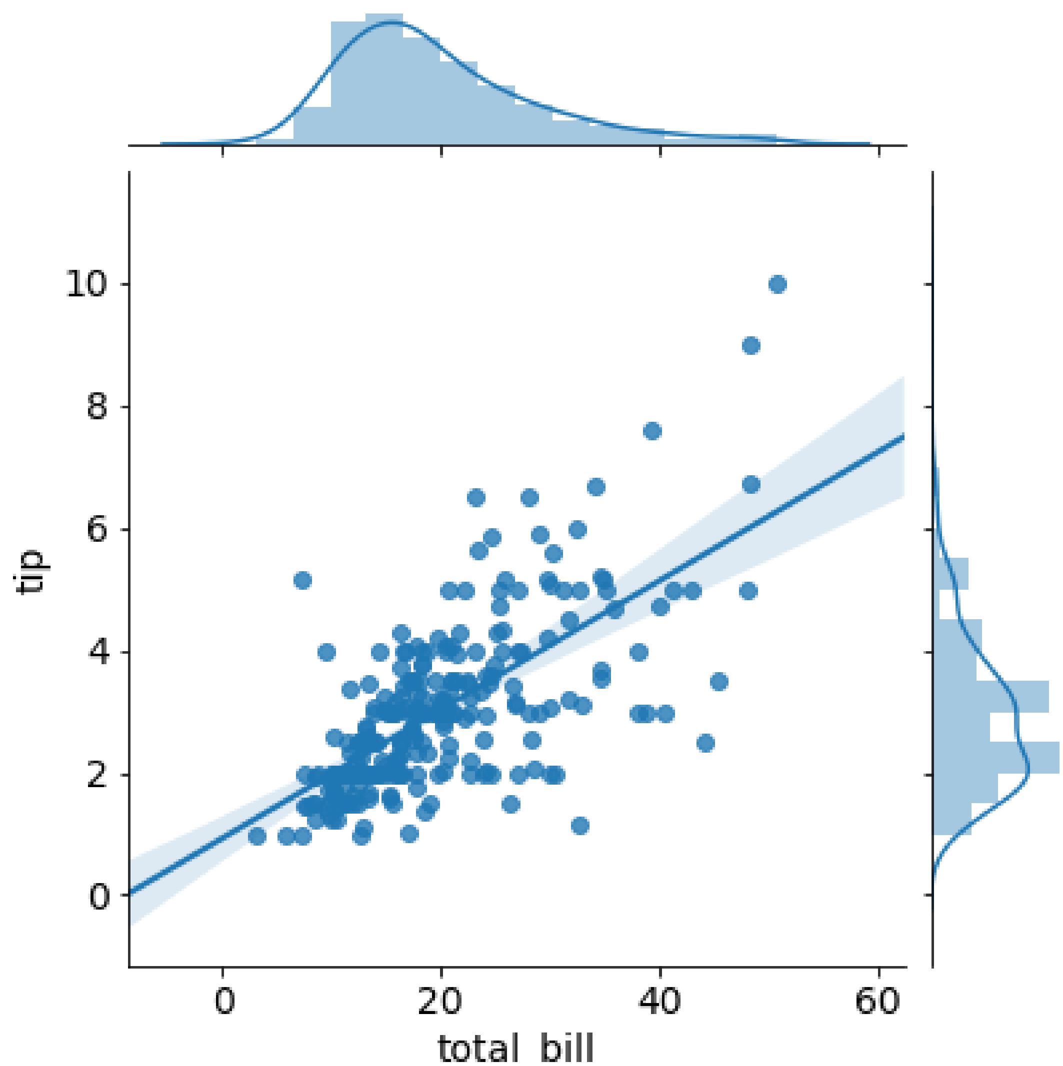
```
the mean of rain-X is 0.51
the mean of rain-Y is 0.51
```

```
In [12]: print('the variance of rain-X is {:.2f}'.format(rain[0].var()))
         print('the variance of rain-Y is {:.2f}'.format(rain[1].var()))
```

```
the variance of rain-X is 0.09
the variance of rain-Y is 0.09
```

5.3 seaborn - weitere Bibliothek zur Datenexploration

```
In [5]: '''seaborn allows easy data exploration'''
        import seaborn as sns
        tips = sns.load_dataset("tips") # Load one of the data sets that come with seaborn
        sns.jointplot("total_bill", "tip", tips, kind='reg');
```

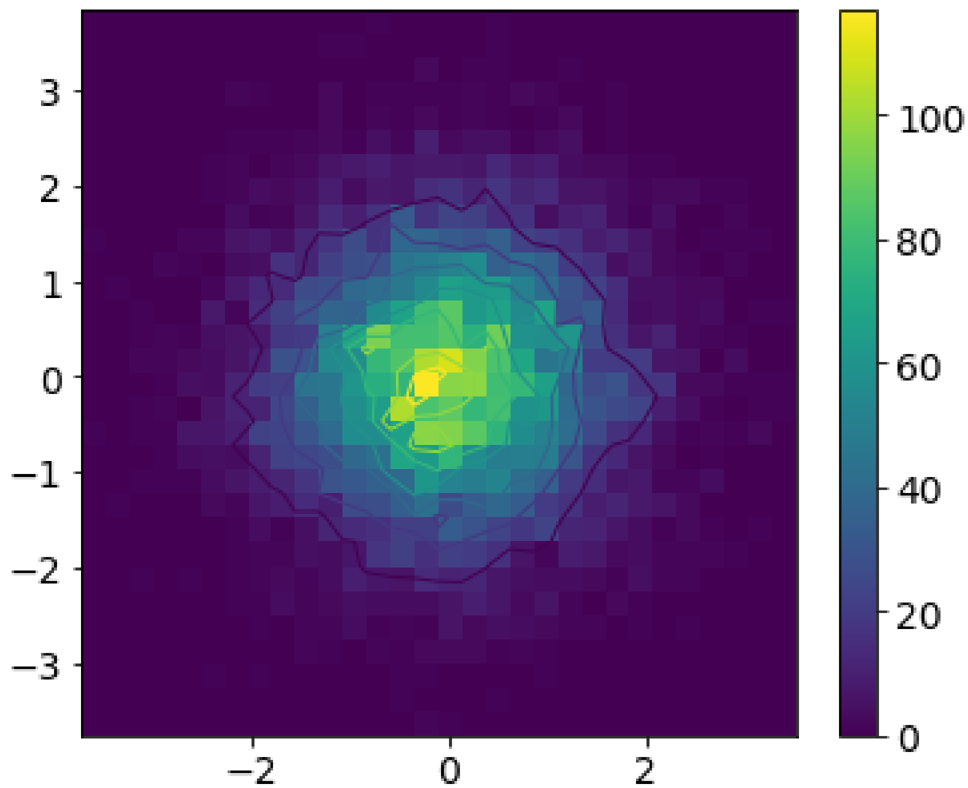


5.4 Dichte-Verteilung: 2D-Histogramm

Bei zu vielen Datenpunkten gibt es analog zum eindimensionalen Fall *Histogramm* die Möglichkeit in die dritte Dimension z die Häufigkeitsverteilung aufzutragen.

Matplotlib hat dazu `hist2d` farbkodiert.

In [6]:
```
'''two dimensional density plot'''
x1 = np.random.normal(size=10000)                 # random x values
x2 = np.random.normal(size=10000)                 # random y values
f = plt.figure(figsize=(6, 5))
counts, xbins, ybins, image = plt.hist2d(x1, x2, bins=[30,30])  # counts-matrix
plt.colorbar()                                    # visualize translation color-number
plt.contour(xbins[:-1], ybins[:-1], counts.T, linewidths=1); # to use for contours
```



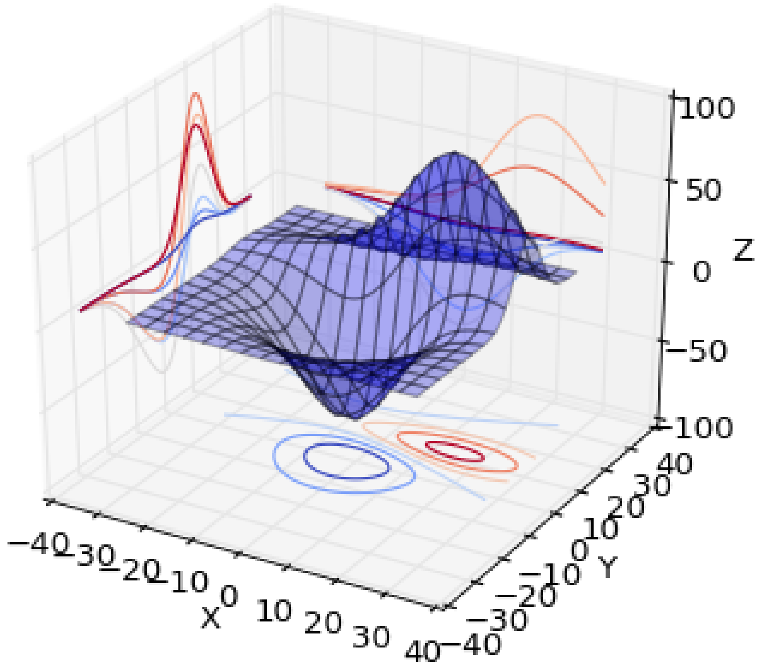

```
plt.hist2d?
```

5.5 3D-Darstellung

zweidimensionale Basis: $y = f(x_1, x_2)$ Graphische Darstellung - diskret: mit *Nadeln* - kontinuierlich: 3D-Graphik

In [13]:

Out[13]:

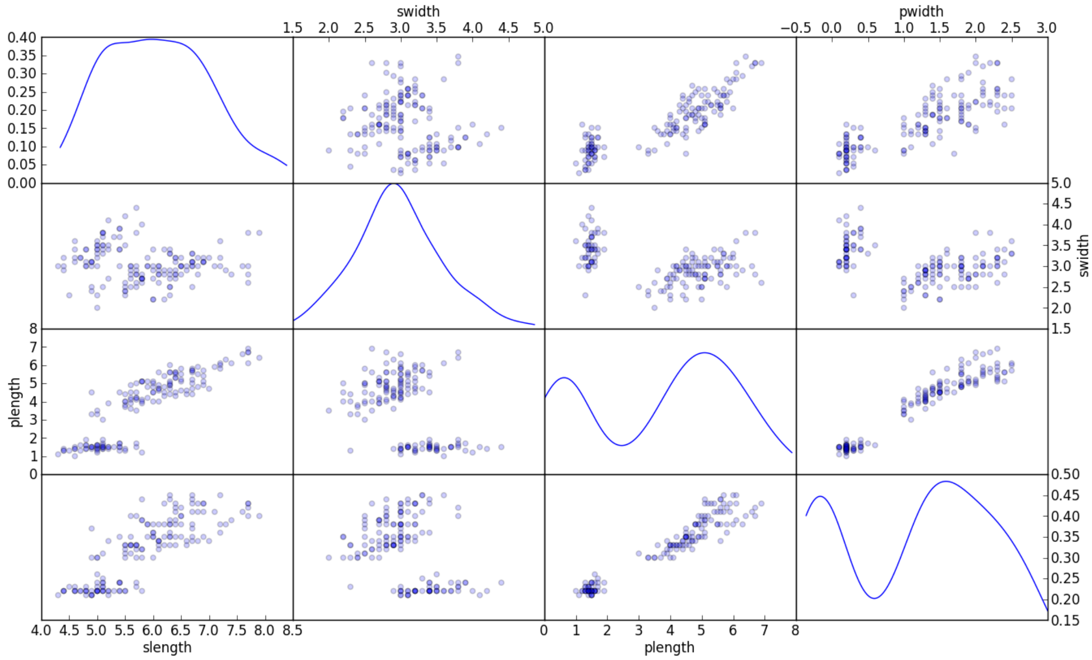


5.6 höherdimensional

- Streumatrix

In [14]:

Out[14]:



6 Zusammenfassung beschreibende mehrdimensionale Statistik

- Datenreduktion KenngröSSen
  - Mittelwerte
  - Standardabweichungen
- Struktur in den Daten erkennen
  - Form der Verteilung
  - Form der Randverteilung
- Anschauliche Darstellung
  - Kontingenztabelle, Vierfeldertafel
  - 2D-Histogramm

Ausblick:

- Abhängigkeit mehrerer Variabler
  - Korrelation
  - Regression

7 Links

- Matplotlib Graphikgalerie http://matplotlib.org/gallery.html
- Pandas Graphiken: http://pandas.pydata.org/pandas-docs/stable/visualization.html

8 Fragen?