Image exploration using Python - essentials

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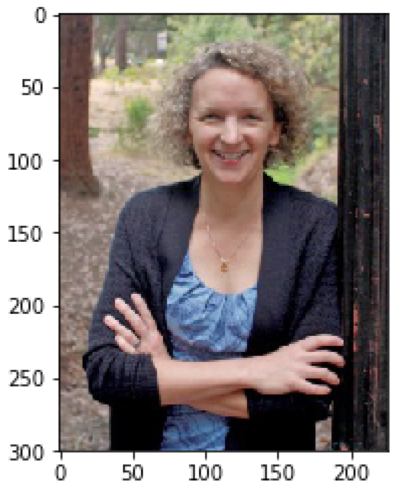
1. Read image from web and scikit-image

In [1]:
```
%matplotlib inline
import numpy as np

from matplotlib import pyplot as plt
from skimage import data, io
```

In [2]:
```
fname = 'http://crl.berkeley.edu/files/2014/04/Holly-226x300.jpg'
imageFromWeb = data.imread(fname, as_grey=False, plugin=None, flatten=No
ne)
plt.imshow(imageFromWeb)
```

Out[2]:
```
<matplotlib.image.AxesImage at 0x1159d0208>
```



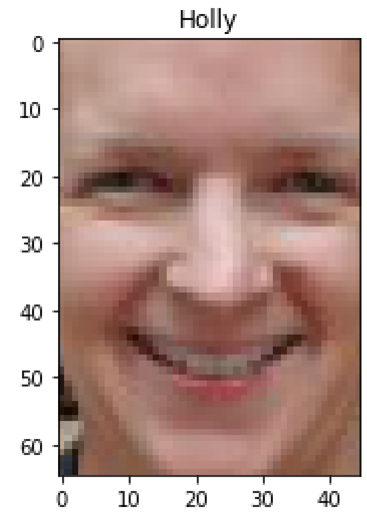
2. Querying image: matrix, sub-matrices, ROI

In [3]:
```
print('----------------------------------------------------------------------
------')
print('Image shape is',imageFromWeb.shape, 'and type is',type(imageFromW
eb))
print('Min =',imageFromWeb.min(),",Mean =",imageFromWeb.mean(),',Max =
',imageFromWeb.max())
print('dtype = ',imageFromWeb.dtype)
print('----------------------------------------------------------------------
------')
```

```
----------------------------------------------------------------------
Image shape is (300, 226, 3) and type is <class 'numpy.ndarray'>
Min = 0 ,Mean = 97.4599016716 ,Max =  255
dtype =  uint8
----------------------------------------------------------------------
```

In [4]:
```
# Cropping an image
facecolor = imageFromWeb[50:115, 95:140]
plt.imshow(facecolor)
plt.title('Holly')
```

Out[4]:
```
<matplotlib.text.Text at 0x115a809b0>
```

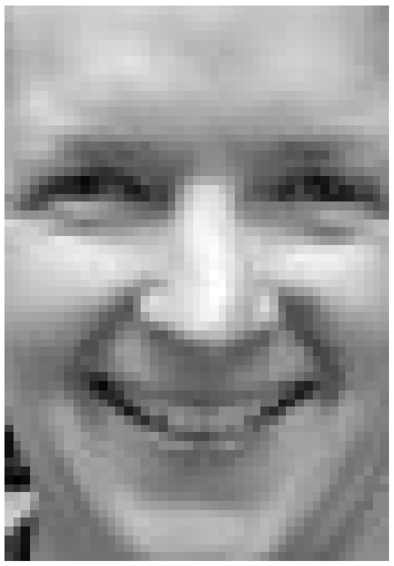


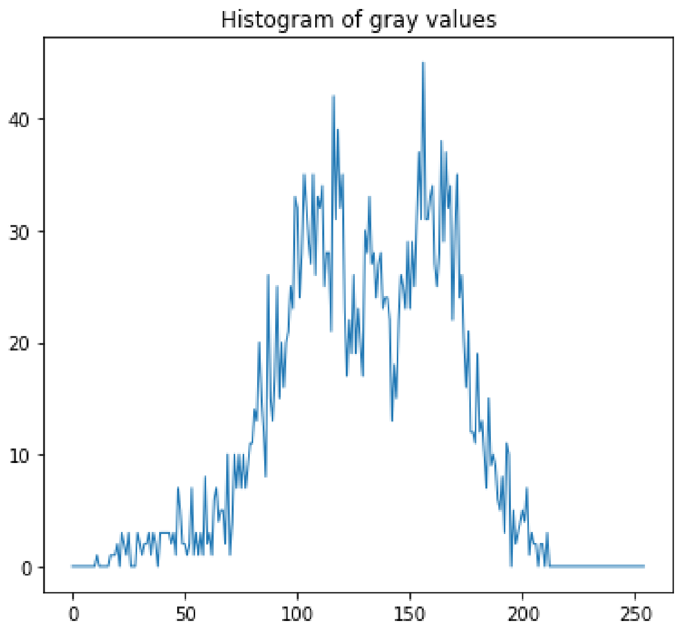
3. Image transformations

In [5]:
```
import numpy as np
import matplotlib.pyplot as plt

from skimage.color import rgb2gray
from skimage.filters import sobel
from skimage.filters.rank import mean, equalize

from skimage.morphology import disk
from skimage import exposure
from skimage.morphology import reconstruction
from skimage import img_as_ubyte, img_as_float
```

In [6]:
```
# Turn color image into grayscale representation
face = rgb2gray(facecolor)
face = img_as_ubyte(face) #this generates the warning

hist = np.histogram(face, bins=np.arange(0, 256))

fig, ax = plt.subplots(ncols=2, figsize=(10, 5))

ax[0].imshow(face, interpolation='nearest', cmap=plt.cm.gray)
ax[0].axis('off')

ax[1].plot(hist[1][:-1], hist[0], lw=1)
ax[1].set_title('Histogram of gray values')

plt.tight_layout()
```

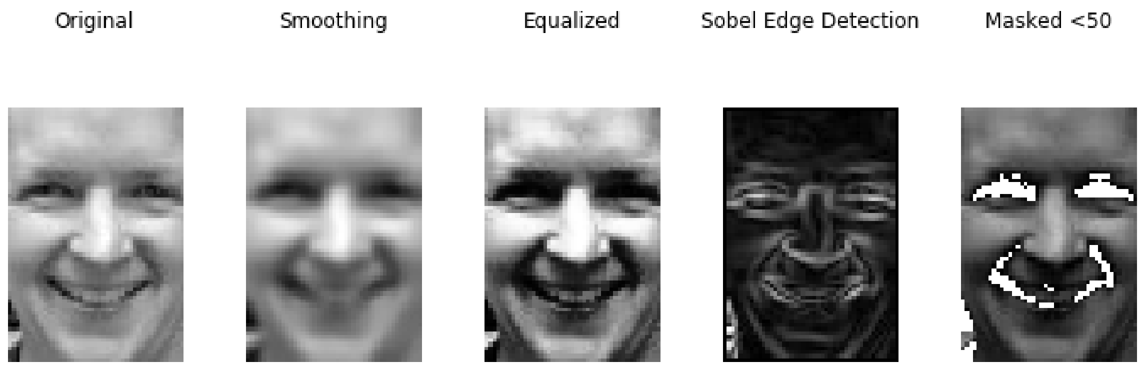
```
/Users/ushizima/anaconda/lib/python3.6/site-packages/skimage/util/dtyp
e.py:122: UserWarning: Possible precision loss when converting from flo
at64 to uint8
  .format(dtypeobj_in, dtypeobj_out))
```





In [7]:
```
# Smoothing
smoothed = img_as_ubyte(mean(face, disk(2)))

#smoothPill = ndi.median_filter(edgesPill.astype(np.uint16), 3)
# Global equalization
equalized = exposure.equalize_hist(face)

# Extract edges
edge_sobel = sobel(face)

# Masking
mask = face < 80
facemask = face.copy()
# Set to "white" (255) pixels where mask is True
facemask[mask] = 255
#facemask = img_as_uint(facemask)
```

In [8]:
```
fig, ax = plt.subplots(ncols=5, sharex=True, sharey=True,
                       figsize=(10, 4))

ax[0].imshow(face, cmap='gray')
ax[0].set_title('Original')

ax[1].imshow(smoothed, cmap='gray')
ax[1].set_title('Smoothing')

ax[2].imshow(equalized, cmap='gray')
ax[2].set_title('Equalized')

ax[3].imshow(edge_sobel, cmap='gray')
ax[3].set_title('Sobel Edge Detection')

ax[4].imshow(facemask, cmap='gray')
ax[4].set_title('Masked <50')

for a in ax:
    a.axis('off')

plt.tight_layout()
plt.show()
```

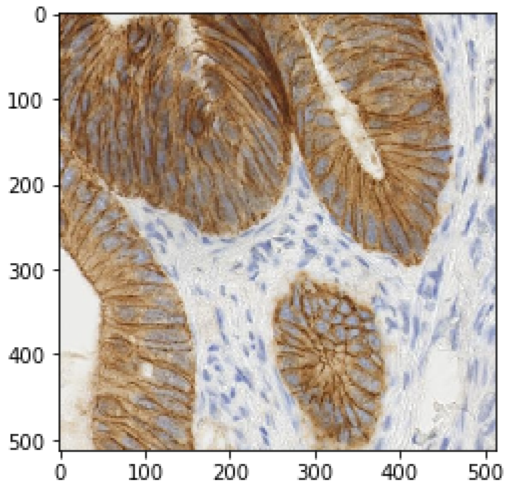


4. Immunohistochemistry example from scikit-image

- More at: http://scikit-image.org/docs/dev/api/skimage.data.html#skimage.data.immunohistochemistry (http://scikit-image.org/docs/dev/api/skimage.data.html#skimage.data.immunohistochemistry)

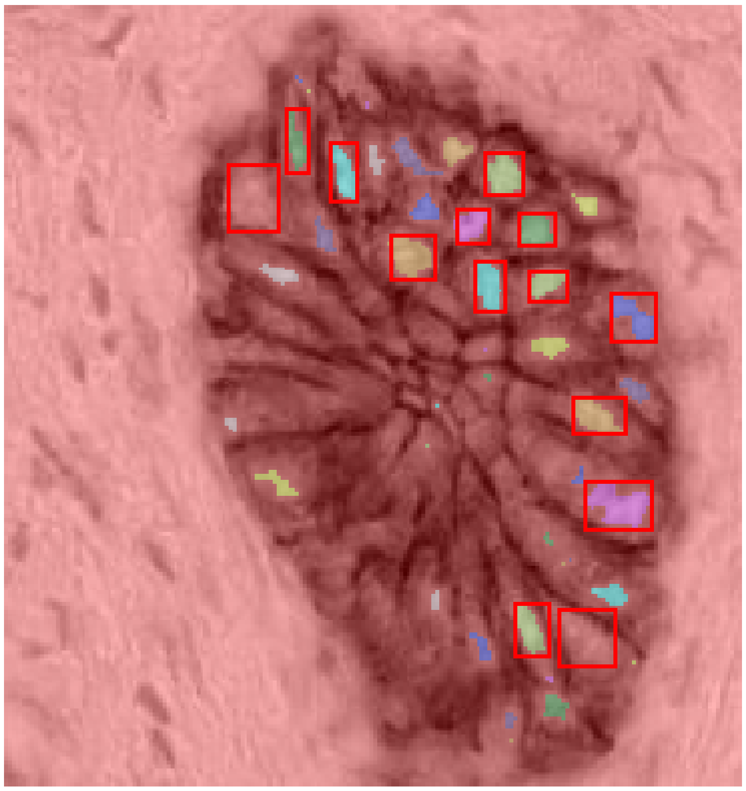
In [9]:
```
imgMicro = data.immunohistochemistry()
plt.imshow(imgMicro)
```

Out[9]:
```
<matplotlib.image.AxesImage at 0x116b06828>
```



5. Segmentation and feature extraction

In [10]:
```
import matplotlib.patches as mpatches

from skimage import data
from skimage.filters import threshold_otsu
from skimage.segmentation import clear_border
from skimage.measure import label, regionprops
from skimage.morphology import closing, square
from skimage.color import label2rgb

# create a subimage for tests
image = imgMicro[300:550, 200:400, 2]

# apply threshold
thresh = threshold_otsu(image)
bw = closing(image > thresh, square(3))

# remove artifacts connected to image border
cleared = clear_border(bw)

# label image regions
label_image = label(cleared)
image_label_overlay = label2rgb(label_image, image=image)

fig, ax = plt.subplots(figsize=(10, 6))
ax.imshow(image_label_overlay)

for region in regionprops(label_image):
    # take regions with large enough areas
    if region.area >= 50:
        # draw rectangle around segmented coins
        minr, minc, maxr, maxc = region.bbox
        rect = mpatches.Rectangle((minc, minr), maxc - minc, maxr - 
minr,
                                  fill=False, edgecolor='red', 
linewidth=2)
        ax.add_patch(rect)

ax.set_axis_off()
plt.tight_layout()
plt.show()
#plt.imshow(bw,cmap=plt.cm.gray)
```



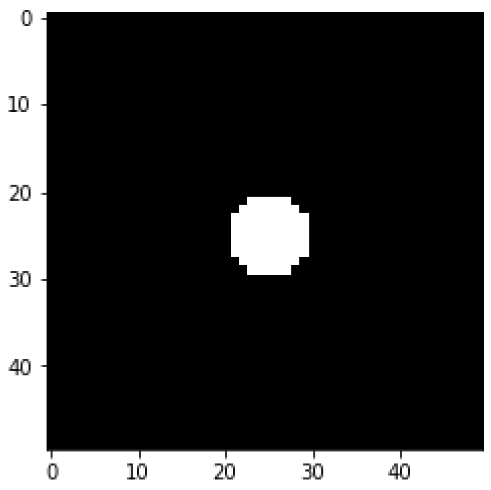
6. Save information as a xls file

In [11]:
```
# Calculate regions properties from label_image
regions = regionprops(label_image)

for i in range(len(regions)):
    all_props = {p:regions[i][p] for p in regions[i] if p not in ('imag
e','convex_image','filled_image')}
    for p, v in list(all_props.items()):
        if isinstance(v,np.ndarray):
            if(len(v.shape)>1):
                del all_props[p]

    for p, v in list(all_props.items()):
        try:
            L = len(v)
        except:
            L = 1
        if L>1:
            del all_props[p]
            for n,entry in enumerate(v):
                all_props[p + str(n)] = entry

    k = ", ".join(all_props.keys())
    v = ", ".join([str(f) for f in all_props.values()]) #notice you need
 to convert numbers to strings
    if(i==0):
        with open('cellsProps.csv','w') as f:
                #f.write(k)
                f.writelines([k,'\n',v,'\n'])
    else:
        with open('cellsProps.csv','a') as f:
            #f.write(k)
            f.writelines([v,'\n'])
```

7. Simulating 2D images - "cells"

```
In [12]: # Test
         from skimage.draw import circle
         img = np.zeros((50, 50), dtype=np.uint8)
         rr, cc = circle(25, 25, 5)
         img[rr, cc] = 1
         plt.imshow(img,cmap='gray')
```

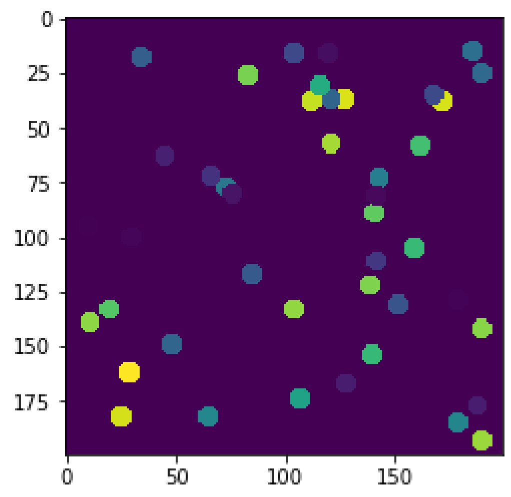
```
Out[12]: <matplotlib.image.AxesImage at 0x117cf1c50>
```



In [13]:
```
%matplotlib inline
import numpy as np

import random
import math
from matplotlib import pyplot as plt
import matplotlib.patches as mpatches
from skimage import data, io
from skimage.draw import circle

def createMyCells(width, height, r, num_cells):

    image = np.zeros((width,height),dtype=np.uint8)
    imgx, imgy = image.shape
    nx = []
    ny = []
    ng = []

    #Creates a synthetic set of points
    for i in range(num_cells):
        nx.append(random.randrange(imgx))
        ny.append(random.randrange(imgy))
        ng.append(random.randrange(256))

    #Uses points as centers of circles
    for i in range(num_cells):
        rr, cc = circle(ny[i], nx[i], radius)
        if valid(ny[i],r,imgy) & valid(nx[i],r,imgx):
            image[rr, cc] = ng[i]
    return image

def valid(v,radius,dim):
    if v<radius:
        return False
    else:
        if v>=dim-radius:
            return False
        else:
            return True
```

In [14]:
```
width = 200
height = 200
radius = 5
num_cells = 50
image = createMyCells(width, height, radius, num_cells)
plt.imshow(image)
```

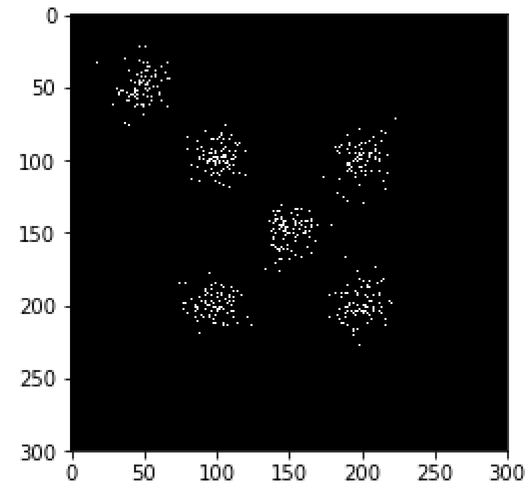
Out[14]:
```
<matplotlib.image.AxesImage at 0x117e52550>
```



8. Simulate particles with Scikit-learn -> sklearn

In [15]:
```
from sklearn.cluster import MeanShift, estimate_bandwidth
from sklearn.datasets.samples_generator import make_blobs
```

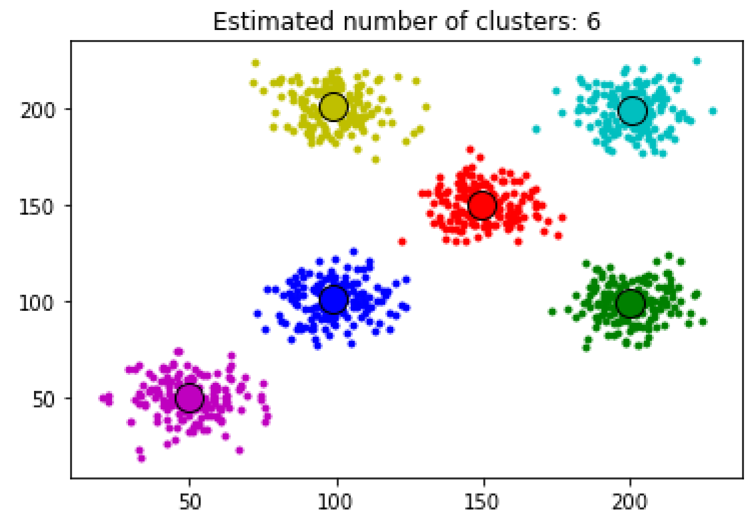
```
In [16]: n = 1000
         clusterSD = 10 #proportional to the pool size
         centers = [[50,50], [100, 100], [100, 200], [150,150], [200, 100],
         [200,200]]
         X, _ = make_blobs(n_samples=n, centers=centers, cluster_std=clusterSD)
         image = np.zeros(shape=(300,300), dtype=np.uint8)
         for i in X:
             x,y=i.astype(np.uint8)
             #print(x,',',y)
             image[x,y]=255
         plt.imshow(image,cmap=plt.cm.gray)

Out[16]: <matplotlib.image.AxesImage at 0x11890a518>
```



```
In [17]: myquantile=0.15 #Change this parameter (smaller numbers will produce sma
         ller clusters and more numerous)

         bandwidth = estimate_bandwidth(X, quantile=myquantile, n_samples=500)

         ms = MeanShift(bandwidth=bandwidth, bin_seeding=True)
         ms.fit(X)
         labels = ms.labels_
         cluster_centers = ms.cluster_centers_

         labels_unique = np.unique(labels)
         n_clusters_ = len(labels_unique)

         print("number of estimated clusters : %d" % n_clusters_)

         number of estimated clusters : 6
```

9. Check particle neighborhood: groups (clustering algorithms)

In [18]:
```
import matplotlib.pyplot as plt
from itertools import cycle

plt.figure(1)
plt.clf()

colors = cycle('bgrcmykbgrcmykbgrcmykbgrcmyk')
for k, col in zip(range(n_clusters_), colors):
    my_members = labels == k
    cluster_center = cluster_centers[k]
    plt.plot(X[my_members, 0], X[my_members, 1], col + '.')
    plt.plot(cluster_center[0], cluster_center[1], 'o',
markerfacecolor=col,
             markeredgecolor='k', markersize=14)
plt.title('Estimated number of clusters: %d' % n_clusters_)
plt.show()
```

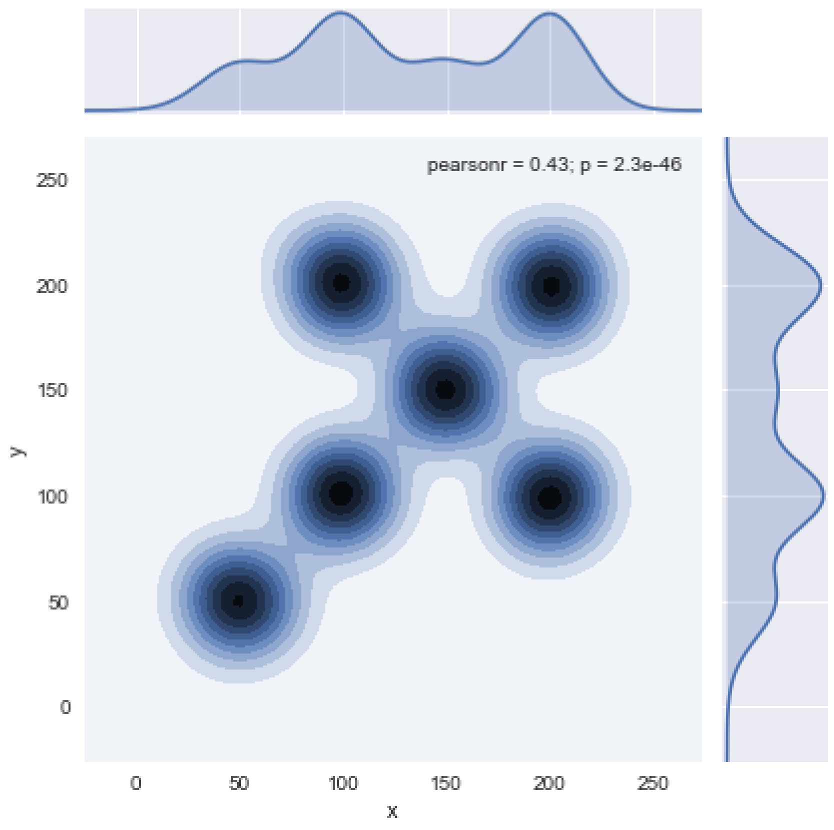


10. Pandas and seaborn

Pandas: http://pandas.pydata.org/ (http://pandas.pydata.org/)

Seaborn: http://seaborn.pydata.org/ (http://seaborn.pydata.org/)

In [19]:
```python
import numpy as np
import pandas as pd
from scipy import stats, integrate
import matplotlib.pyplot as plt
import seaborn as sns

df = pd.DataFrame(X, columns=["x", "y"])
# Kernel density estimation
sns.jointplot(x="x", y="y", data=df, kind="kde");
```



In [ ]: